

(2)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)**(19) World Intellectual Property Organization
International Bureau****(43) International Publication Date
3 May 2001 (03.05.2001)****PCT****(10) International Publication Number
WO 01/31051 A2**

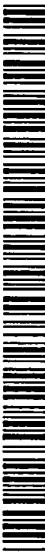
- (51) International Patent Classification⁷:** C12Q **(81) Designated States (national):** AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (21) International Application Number:** PCT/US00/41381
- (22) International Filing Date:** 20 October 2000 (20.10.2000)
- (25) Filing Language:** English
- (26) Publication Language:** English
- (30) Priority Data:**
09/429,322 26 October 1999 (26.10.1999) US
- (71) Applicant (for all designated States except US):** ISIS PHARMACEUTICALS, INC. [US/US]; 2292 Faraday Avenue, Carlsbad, CA 92008 (US).
- (72) Inventors; and**
- (75) Inventors/Applicants (for US only):** BENNETT, C., Frank [US/US]; 1347 Cassins Street, Carlsbad, CA 92008 (US). COWSERT, Lex, M. [US/US]; 3008 Newshire Street, Carlsbad, CA 92008 (US).
- (74) Agents:** LICATA, Jane, Massey et al.; 66 E. Main Street, Marlton, NJ 08053 (US).

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

**A2****(54) Title: ANTISENSE MODULATION OF PROTEIN KINASE C-THETA EXPRESSION**

(57) Abstract: Antisense compounds, compositions and methods are provided for modulating the expression of Protein kinase C-theta. The compositions comprise antisense compounds, particularly antisense oligonucleotides, targeted to nucleic acids encoding Protein kinase C-theta. Methods of using these compounds for modulation of Protein kinase C-theta expression and for treatment of diseases associated with expression of Protein kinase C-theta are provided.

WO 01/31051

ANTISENSE MODULATION OF PROTEIN KINASE C-THETA EXPRESSION**FIELD OF THE INVENTION**

The present invention provides compositions and methods for modulating the expression of Protein kinase C-theta. In particular, this invention relates to antisense compounds, particularly oligonucleotides, specifically hybridizable with nucleic acids encoding human Protein kinase C-theta. Such oligonucleotides have been shown to modulate the expression of Protein kinase C-theta.

BACKGROUND OF THE INVENTION

One of the principal mechanisms by which cellular regulation is effected is through the transduction of extracellular signals across the membrane that in turn modulate biochemical pathways within the cell. Protein phosphorylation, orchestrated by enzymes known as kinases, represents one course by which intracellular signals are propagated from molecule to molecule resulting in a cellular response. These signal transduction cascades are highly regulated and often overlapping as evidenced by the existence of many protein kinases as well as phosphatases, which remove phosphate moieties. It is currently believed that a number of disease states and/or disorders are a result of either aberrant activation or functional mutations in the molecular components of kinase cascades. Consequently, considerable attention has been devoted to the characterization of these proteins.

One major kinase signal transduction pathway involves the enzyme known as protein kinase C. Protein kinase C (PKC) is a family of enzymes that are physiologically activated by 1,2-diacylglycerol (DAG) and other lipids. When activated, the isozymes bind to membrane phospholipids or to membrane receptors and anchor the enzymes in a subcellular compartment reviewed in (Liu and Heckman, *Cell.* 35 *Signal.*, 1998, 10, 529-542).

-2-

Protein kinase C isozymes differ in number and expression level in different cell lines and tissues. To date, 11 different isozymes (alpha, betaI, betaII, gamma, delta, epsilon, nu, lambda, mu, theta and zeta) have been 5 identified and they have been divided into three groups based on their differential expression patterns and cofactor requirements. Interest in protein kinase C as a therapeutic target was generated by the finding that it is the major cellular receptor through which a class of tumor-10 promoting agents called phorbol esters exert their pleiotropic effects on cells (Liu and Heckman, *Cell. Signal.*, 1998, 10, 529-542).

Protein kinase C-theta (also known as PKC-θ, PKC θ , PRKCT, nPKC-theta and PRKCQ), one of the novel 15 serine/threonine protein kinase C isoforms (nPKC), is expressed ubiquitously in tissues with the highest levels found in hematopoietic cell lines, including T-cells and thymocytes. (Baier et al., *J. Biol. Chem.*, 1993, 268, 4997-5004; Keenan et al., *Immunology*, 1997, 90, 557-563; 20 Meller et al., *Cell. Immunol.*, 1999, 193, 185-193; Wang et al., *Biochem. Biophys. Res. Commun.*, 1993, 191, 240-246). This isozyme has been shown to function in a calcium-independent fashion, and transient overexpression of the 25 protein in murine thymoma cells resulted in transcriptional activation of an interleukin-2 promoter-driven construct (Baier et al., *Eur. J. Biochem.*, 1994, 225, 195-203), indicating a role for protein kinase C-theta in T-cell signaling pathways.

Subsequent characterization of the role of protein 30 kinase C-theta in T-cell systems has shown that it is also involved in cell cycle control (Resnick et al., *J. Biol. Chem.*, 1998, 273, 27654-27661), cellular activation (Monks et al., *Nature*, 1997, 385, 83-86), AP1 transcription factor stimulation (Baier-Bitterlich et al., *Mol. Cell. Biol.*,

- 3 -

1996, 16, 1842-1850), and the etiology of AIDS (Smith et al., *J. Biol. Chem.*, 1996, 271, 16753-16757). The human protein kinase C-theta gene has been localized to chromosome 10p15. This finding is noteworthy since 5 deletions and translocations in this chromosomal region have been associated with several human T-cell disorders (Erdel et al., *Genomics*, 1995, 25, 595-597; Kofler et al., *Mol. Gen. Genet.*, 1998, 259, 398-403). Methods to modulate 10 the immune response, particularly the activity and differentiation of T-cells, are disclosed in US Patent number 5,776,716. These methods involve the use of peptides to block interactions of protein kinase C-theta with fyn, a receptor for the activated protein kinase C-theta enzyme (Ron et al., 1998).

15 Protein kinase C-theta has been shown to be an upstream activator of the c-Jun-N-terminal kinase/stress-activated protein kinase (JNK/SAPK) pathway. This pathway was originally identified as an oncogene- and ultraviolet light-stimulated kinase pathway but is now known to be 20 activated by growth factors, cytokines and T-cell costimulation (Moriguchi et al., *Adv. Pharmacol.*, 1996, 36, 121-137). Expression of a constitutively active form of protein kinase C-theta resulted in strong activation of the JNK/SAPK pathway in Jurkat T-cells, while a dominant 25 negative form interfered with activation of interleukin-2 promoter transcription (Ghaffari-Tabrizi et al., *Eur. J. Immunol.*, 1999, 29, 132-142). This pathway has been further characterized and shown to be activated only in conjunction with a calcium signal delivered through the 30 protein calcineurin (Avraham et al., *Eur. J. Immunol.*, 1998, 28, 2320-2330).

Protein kinase C-theta has also been implicated in other cellular processes including apoptosis (Datta et al., *J. Biol. Chem.*, 1997, 272, 20317-20320), cytoskeletal

- 4 -

arrangement (Pietromonaco et al., *J. Biol. Chem.*, 1998, 273, 7594-7603; Simons et al., *Biochem. Biophys. Res. Commun.*, 1998, 253, 561-565), proliferation (Passalacqua et al., *Biochem. J.*, 1999, 337, 113-118), and angiogenesis and 5 wound repair (Tang et al., *J. Biol. Chem.*, 1997, 272, 28704-28711). In rat models, protein kinase C-theta has been shown to be involved in insulin signaling (Griffin et al., *Diabetes*, 1999, 48, 1270-1274) and it is currently believed to play a role in the development of diabetes in 10 humans (Kellerer et al., *Diabetologia*, 1998, 41, 833-838). The pharmacological modulation of protein kinase C-theta expression may therefore be an appropriate point of therapeutic intervention in pathological conditions.

Currently, there are no known therapeutic agents 15 which effectively inhibit the synthesis of protein kinase C-theta and investigative strategies aimed at modulating the PKC family of isozymes have involved the use of antisense oligonucleotides and PKC inhibitors such as staurosporine, which generally and nonspecifically inhibits 20 PKC isoforms. Combination treatments of the two are disclosed in the PCT publication WO 98/07415 and WO 97/32589. However, the antisense compounds listed only target protein kinase C-alpha mRNA (Müller et al., 1997; Prescott, 1998).

25 Antisense mediated inhibition of PKC isoforms is also disclosed in US Patent Nos 5,703,054 and 5,885,970 (Bennett and Dean, 1999; Bennett and Dean, 1997) as well as the PCT publication WO 95/02069 and DE 19740384A1 (Bennett et al., 1995; Haller, 1999). Oligomers comprised of subunits, of 30 which one subunit is a protein nucleic acid, targeting protein kinase C isoforms are disclosed in the PCT publication WO 95/03833 (Dean, 1995). However these studies involve inhibition of specific isoforms and do not include the protein kinase C-theta isozyme. Consequently,

-5-

there remains a long felt need for additional agents capable of effectively inhibiting protein kinase C-theta function.

Antisense technology is emerging as an effective
5 means for reducing the expression of specific gene products and may therefore prove to be uniquely useful in a number of therapeutic, diagnostic, and research applications for the modulation of protein kinase C-theta expression.

The present invention provides compositions and
10 methods for modulating protein kinase C-theta expression.

SUMMARY OF THE INVENTION

The present invention is directed to antisense compounds, particularly oligonucleotides, which are targeted to a nucleic acid encoding Protein kinase C-theta, 15 and which modulate the expression of Protein kinase C-theta. Pharmaceutical and other compositions comprising the antisense compounds of the invention are also provided. Further provided are methods of modulating the expression of Protein kinase C-theta in cells or tissues comprising 20 contacting said cells or tissues with one or more of the antisense compounds or compositions of the invention. Further provided are methods of treating an animal, particularly a human, suspected of having or being prone to a disease or condition associated with expression of 25 Protein kinase C-theta by administering a therapeutically or prophylactically effective amount of one or more of the antisense compounds or compositions of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention employs oligomeric antisense 30 compounds, particularly oligonucleotides, for use in modulating the function of nucleic acid molecules encoding Protein kinase C-theta, ultimately modulating the amount of Protein kinase C-theta produced. This is accomplished by providing antisense compounds which specifically hybridize 35 with one or more nucleic acids encoding Protein kinase C-

-6-

theta. As used herein, the terms "target nucleic acid" and "nucleic acid encoding Protein kinase C-theta" encompass DNA encoding Protein kinase C-theta, RNA (including pre-mRNA and mRNA) transcribed from such DNA, and also cDNA derived from such RNA. The specific hybridization of an oligomeric compound with its target nucleic acid interferes with the normal function of the nucleic acid. This modulation of function of a target nucleic acid by compounds which specifically hybridize to it is generally referred to as "antisense". The functions of DNA to be interfered with include replication and transcription. The functions of RNA to be interfered with include all vital functions such as, for example, translocation of the RNA to the site of protein translation, translation of protein from the RNA, splicing of the RNA to yield one or more mRNA species, and catalytic activity which may be engaged in or facilitated by the RNA. The overall effect of such interference with target nucleic acid function is modulation of the expression of Protein kinase C-theta. In the context of the present invention, "modulation" means either an increase (stimulation) or a decrease (inhibition) in the expression of a gene. In the context of the present invention, inhibition is the preferred form of modulation of gene expression and mRNA is a preferred target.

It is preferred to target specific nucleic acids for antisense. "Targeting" an antisense compound to a particular nucleic acid, in the context of this invention, is a multistep process. The process usually begins with the identification of a nucleic acid sequence whose function is to be modulated. This may be, for example, a cellular gene (or mRNA transcribed from the gene) whose expression is associated with a particular disorder or disease state, or a nucleic acid molecule from an infectious agent. In the present invention, the target is a nucleic acid molecule encoding Protein kinase C-theta.

- 7 -

The targeting process also includes determination of a site or sites within this gene for the antisense interaction to occur such that the desired effect, e.g., detection or modulation of expression of the protein, will result.

5 Within the context of the present invention, a preferred intragenic site is the region encompassing the translation initiation or termination codon of the open reading frame (ORF) of the gene. Since, as is known in the art, the translation initiation codon is typically 5'-AUG (in

10 transcribed mRNA molecules; 5'-ATG in the corresponding DNA molecule), the translation initiation codon is also referred to as the "AUG codon," the "start codon" or the "AUG start codon". A minority of genes have a translation initiation codon having the RNA sequence 5'-GUG, 5'-UUG or

15 5'-CUG, and 5'-AUA, 5'-ACG and 5'-CUG have been shown to function in vivo. Thus, the terms "translation initiation codon" and "start codon" can encompass many codon sequences, even though the initiator amino acid in each instance is typically methionine (in eukaryotes) or

20 formylmethionine (in prokaryotes). It is also known in the art that eukaryotic and prokaryotic genes may have two or more alternative start codons, any one of which may be preferentially utilized for translation initiation in a particular cell type or tissue, or under a particular set

25 of conditions. In the context of the invention, "start codon" and "translation initiation codon" refer to the codon or codons that are used in vivo to initiate translation of an mRNA molecule transcribed from a gene encoding Protein kinase C-theta, regardless of the

30 sequence(s) of such codons.

It is also known in the art that a translation termination codon (or "stop codon") of a gene may have one of three sequences, i.e., 5'-UAA, 5'-UAG and 5'-UGA (the corresponding DNA sequences are 5'-TAA, 5'-TAG and 5'-TGA, respectively). The terms "start codon region" and

-8-

"translation initiation codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation initiation codon. Similarly, 5 the terms "stop codon region" and "translation termination codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation termination codon.

10 The open reading frame (ORF) or "coding region," which is known in the art to refer to the region between the translation initiation codon and the translation termination codon, is also a region which may be targeted effectively. Other target regions include the 5' 15 untranslated region (5'UTR), known in the art to refer to the portion of an mRNA in the 5' direction from the translation initiation codon, and thus including nucleotides between the 5' cap site and the translation initiation codon of an mRNA or corresponding nucleotides on 20 the gene, and the 3' untranslated region (3'UTR), known in the art to refer to the portion of an mRNA in the 3' direction from the translation termination codon, and thus including nucleotides between the translation termination codon and 3' end of an mRNA or corresponding nucleotides on 25 the gene. The 5' cap of an mRNA comprises an N7-methylated guanosine residue joined to the 5'-most residue of the mRNA via a 5'-5' triphosphate linkage. The 5' cap region of an mRNA is considered to include the 5' cap structure itself as well as the first 50 nucleotides adjacent to the cap. 30 The 5' cap region may also be a preferred target region.

Although some eukaryotic mRNA transcripts are directly translated, many contain one or more regions, known as "introns," which are excised from a transcript before it is translated. The remaining (and therefore 35 translated) regions are known as "exons" and are spliced

-9-

together to form a continuous mRNA sequence. mRNA splice sites, i.e., intron-exon junctions, may also be preferred target regions, and are particularly useful in situations where aberrant splicing is implicated in disease, or where
5 an overproduction of a particular mRNA splice product is implicated in disease. Aberrant fusion junctions due to rearrangements or deletions are also preferred targets. It has also been found that introns can also be effective, and therefore preferred, target regions for antisense compounds
10 targeted, for example, to DNA or pre-mRNA.

Once one or more target sites have been identified, oligonucleotides are chosen which are sufficiently complementary to the target, i.e., hybridize sufficiently well and with sufficient specificity, to give the desired
15 effect.

In the context of this invention, "hybridization" means hydrogen bonding, which may be Watson-Crick, Hoogsteen or reversed Hoogsteen hydrogen bonding, between complementary nucleoside or nucleotide bases. For example,
20 adenine and thymine are complementary nucleobases which pair through the formation of hydrogen bonds.
"Complementary," as used herein, refers to the capacity for precise pairing between two nucleotides. For example, if a nucleotide at a certain position of an oligonucleotide is
25 capable of hydrogen bonding with a nucleotide at the same position of a DNA or RNA molecule, then the oligonucleotide and the DNA or RNA are considered to be complementary to each other at that position. The oligonucleotide and the DNA or RNA are complementary to each other when a
30 sufficient number of corresponding positions in each molecule are occupied by nucleotides which can hydrogen bond with each other. Thus, "specifically hybridizable" and "complementary" are terms which are used to indicate a sufficient degree of complementarity or precise pairing
35 such that stable and specific binding occurs between the

-10-

oligonucleotide and the DNA or RNA target. It is understood in the art that the sequence of an antisense compound need not be 100% complementary to that of its target nucleic acid to be specifically hybridizable. An 5 antisense compound is specifically hybridizable when binding of the compound to the target DNA or RNA molecule interferes with the normal function of the target DNA or RNA to cause a loss of utility, and there is a sufficient degree of complementarity to avoid non-specific binding of 10 the antisense compound to non-target sequences under conditions in which specific binding is desired, i.e., under physiological conditions in the case of in vivo assays or therapeutic treatment, and in the case of in vitro assays, under conditions in which the assays are 15 performed.

Antisense compounds are commonly used as research reagents and diagnostics. For example, antisense oligonucleotides, which are able to inhibit gene expression with exquisite specificity, are often used by those of 20 ordinary skill to elucidate the function of particular genes. Antisense compounds are also used, for example, to distinguish between functions of various members of a biological pathway. Antisense modulation has, therefore, been harnessed for research use.

25 The specificity and sensitivity of antisense is also harnessed by those of skill in the art for therapeutic uses. Antisense oligonucleotides have been employed as therapeutic moieties in the treatment of disease states in animals and man. Antisense oligonucleotides have been 30 safely and effectively administered to humans and numerous clinical trials are presently underway. It is thus established that oligonucleotides can be useful therapeutic modalities that can be configured to be useful in treatment regimes for treatment of cells, tissues and animals, 35 especially humans.

-11-

In the context of this invention, the term "oligonucleotide" refers to an oligomer or polymer of ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) or mimetics thereof. This term includes oligonucleotides composed of naturally-occurring nucleobases, sugars and covalent internucleoside (backbone) linkages as well as oligonucleotides having non-naturally-occurring portions which function similarly. Such modified or substituted oligonucleotides are often preferred over native forms because of desirable properties such as, for example, enhanced cellular uptake, enhanced affinity for nucleic acid target and increased stability in the presence of nucleases.

While antisense oligonucleotides are a preferred form of antisense compound, the present invention comprehends other oligomeric antisense compounds, including but not limited to oligonucleotide mimetics such as are described below. The antisense compounds in accordance with this invention preferably comprise from about 8 to about 30 nucleobases (i.e. from about 8 to about 30 linked nucleosides). Particularly preferred antisense compounds are antisense oligonucleotides, even more preferably those comprising from about 12 to about 25 nucleobases. As is known in the art, a nucleoside is a base-sugar combination. The base portion of the nucleoside is normally a heterocyclic base. The two most common classes of such heterocyclic bases are the purines and the pyrimidines. Nucleotides are nucleosides that further include a phosphate group covalently linked to the sugar portion of the nucleoside. For those nucleosides that include a pentofuranosyl sugar, the phosphate group can be linked to either the 2', 3' or 5' hydroxyl moiety of the sugar. In forming oligonucleotides, the phosphate groups covalently link adjacent nucleosides to one another to form a linear polymeric compound. In turn the respective ends of this

-12-

linear polymeric structure can be further joined to form a circular structure, however, open linear structures are generally preferred. Within the oligonucleotide structure, the phosphate groups are commonly referred to as forming 5 the internucleoside backbone of the oligonucleotide. The normal linkage or backbone of RNA and DNA is a 3' to 5' phosphodiester linkage.

Specific examples of preferred antisense compounds useful in this invention include oligonucleotides 10 containing modified backbones or non-natural internucleoside linkages. As defined in this specification, oligonucleotides having modified backbones include those that retain a phosphorus atom in the backbone and those that do not have a phosphorus atom in the 15 backbone. For the purposes of this specification, and as sometimes referenced in the art, modified oligonucleotides that do not have a phosphorus atom in their internucleoside backbone can also be considered to be oligonucleosides.

Preferred modified oligonucleotide backbones include, 20 for example, phosphorothioates, chiral phosphorothioates, phosphorodithioates, phototriesters, aminoalkyl-phosphotriesters, methyl and other alkyl phosphonates including 3'-alkylene phosphonates and chiral phosphonates, phosphinates, phosphoramidates including 3'-amino 25 phosphoramidate and aminoalkylphosphoramidates, thionophosphoramidates, thionoalkylphosphonates, thionoalkylphosphotriesters, and boranophosphates having normal 3'-5' linkages, 2'-5' linked analogs of these, and those having inverted polarity wherein the adjacent pairs 30 of nucleoside units are linked 3'-5' to 5'-3' or 2'-5' to 5'-2'. Various salts, mixed salts and free acid forms are also included.

Representative United States patents that teach the preparation of the above phosphorus-containing linkages 35 include, but are not limited to, U.S.: 3,687,808;

-13-

4,469,863; 4,476,301; 5,023,243; 5,177,196; 5,188,897;
5,264,423; 5,276,019; 5,278,302; 5,286,717; 5,321,131;
5,399,676; 5,405,939; 5,453,496; 5,455,233; 5,466,677;
5,476,925; 5,519,126; 5,536,821; 5,541,306; 5,550,111;
5 5,563,253; 5,571,799; 5,587,361; and 5,625,050, certain of
which are commonly owned with this application, and each of
which is herein incorporated by reference.

Preferred modified oligonucleotide backbones that do not include a phosphorus atom therein have backbones that
10 are formed by short chain alkyl or cycloalkyl internucleoside linkages, mixed heteroatom and alkyl or cycloalkyl internucleoside linkages, or one or more short chain heteroatomic or heterocyclic internucleoside linkages. These include those having morpholino linkages
15 (formed in part from the sugar portion of a nucleoside); siloxane backbones; sulfide, sulfoxide and sulfone backbones; formacetyl and thioformacetyl backbones; methylene formacetyl and thioformacetyl backbones; alkene containing backbones; sulfamate backbones; methyleneimino
20 and methylenehydrazino backbones; sulfonate and sulfonamide backbones; amide backbones; and others having mixed N, O, S and CH₂ component parts.

Representative United States patents that teach the preparation of the above oligonucleosides include, but are
25 not limited to, U.S.: 5,034,506; 5,166,315; 5,185,444; 5,214,134; 5,216,141; 5,235,033; 5,264,562; 5,264,564; 5,405,938; 5,434,257; 5,466,677; 5,470,967; 5,489,677; 5,541,307; 5,561,225; 5,596,086; 5,602,240; 5,610,289; 5,602,240; 5,608,046; 5,610,289; 5,618,704; 5,623,070;
30 5,663,312; 5,633,360; 5,677,437; and 5,677,439, certain of which are commonly owned with this application, and each of which is herein incorporated by reference.

In other preferred oligonucleotide mimetics, both the sugar and the internucleoside linkage, i.e., the backbone,
35 of the nucleotide units are replaced with novel groups.

-14-

The base units are maintained for hybridization with an appropriate nucleic acid target compound. One such oligomeric compound, an oligonucleotide mimetic that has been shown to have excellent hybridization properties, is 5 referred to as a peptide nucleic acid (PNA). In PNA compounds, the sugar-backbone of an oligonucleotide is replaced with an amide containing backbone, in particular an aminoethylglycine backbone. The nucleobases are retained and are bound directly or indirectly to aza 10 nitrogen atoms of the amide portion of the backbone. Representative United States patents that teach the preparation of PNA compounds include, but are not limited to, U.S.: 5,539,082; 5,714,331; and 5,719,262, each of which is herein incorporated by reference. Further teaching 15 of PNA compounds can be found in Nielsen et al., *Science*, 1991, 254, 1497-1500.

Most preferred embodiments of the invention are oligonucleotides with phosphorothioate backbones and oligonucleosides with heteroatom backbones, and in 20 particular -CH₂-NH-O-CH₂-, -CH₂-N(CH₃)₂-O-CH₂- [known as a methylene (methylimino) or MMI backbone], -CH₂-O-N(CH₃)₂-CH₂-, -CH₂-N(CH₃)₂-N(CH₃)₂-CH₂- and -O-N(CH₃)₂-CH₂-CH₂- [wherein the native phosphodiester backbone is represented as -O-P(=O)-CH₂-] of the above referenced U.S. patent 5,489,677, and the 25 amide backbones of the above referenced U.S. patent 5,602,240. Also preferred are oligonucleotides having morpholino backbone structures of the above-referenced U.S. patent 5,034,506.

Modified oligonucleotides may also contain one or 30 more substituted sugar moieties. Preferred oligonucleotides comprise one of the following at the 2' position: OH; F; O-, S-, or N-alkyl; O-, S-, or N-alkenyl; O-, S- or N-alkynyl; or O-alkyl-O-alkyl, wherein the alkyl, alkenyl and alkynyl may be substituted or unsubstituted C₁ 35 to C₁₀ alkyl or C₂ to C₁₀ alkenyl and alkynyl. Particularly

-15-

preferred are $O[(CH_2)_nO]_mCH_3$, $O(CH_2)_nOCH_3$, $O(CH_2)_nNH_2$, $O(CH_2)_nCH_3$, $O(CH_2)_nONH_2$, and $O(CH_2)_nON[(CH_2)_nCH_3]_2$, where n and m are from 1 to about 10. Other preferred oligonucleotides comprise one of the following at the 2' position: C₁ to C₁₀,

5 lower alkyl, substituted lower alkyl, alkaryl, aralkyl, O-alkaryl or O-aralkyl, SH, SCH₃, OCN, Cl, Br, CN, CF₃, OCF₃, SOCH₃, SO₂CH₃, ONO₂, NO₂, N₃, NH₂, heterocycloalkyl, heterocycloalkaryl, aminoalkylamino, polyalkylamino, substituted silyl, an RNA cleaving group, a reporter group,

10 an intercalator, a group for improving the pharmacokinetic properties of an oligonucleotide, or a group for improving the pharmacodynamic properties of an oligonucleotide, and other substituents having similar properties. A preferred modification includes 2'-methoxyethoxy (2'-O-CH₂CH₂OCH₃, also known as 2'-O-(2-methoxyethyl) or 2'-MOE) (Martin et al., *Helv. Chim. Acta*, 1995, 78, 486-504) i.e., an alkoxyalkoxy group. A further preferred modification includes 2'-dimethylaminoxyethoxy, i.e., a O(CH₂)₂ON(CH₃)₂ group, also known as 2'-DMAOE, as described in examples hereinbelow,

15 20 and 2'-dimethylaminoethoxyethoxy (also known in the art as 2'-O-dimethylaminoethoxyethyl or 2'-DMAEOE), i.e., 2'-O-CH₂-O-CH₂-N(CH₃)₂, also described in examples hereinbelow.

Other preferred modifications include 2'-methoxy (2'-O-CH₃), 2'-aminopropoxy (2'-OCH₂CH₂CH₂NH₂) and 2'-fluoro (2'-F). Similar modifications may also be made at other positions on the oligonucleotide, particularly the 3' position of the sugar on the 3' terminal nucleotide or in 2'-5' linked oligonucleotides and the 5' position of 5' terminal nucleotide. Oligonucleotides may also have sugar mimetics such as cyclobutyl moieties in place of the pentofuranosyl sugar. Representative United States patents that teach the preparation of such modified sugar structures include, but are not limited to, U.S.:

4,981,957; 5,118,800; 5,319,080; 5,359,044; 5,393,878;

35 5,446,137; 5,466,786; 5,514,785; 5,519,134; 5,567,811;

-16-

5,576,427; 5,591,722; 5,597,909; 5,610,300; 5,627,053;
5,639,873; 5,646,265; 5,658,873; 5,670,633; and 5,700,920,
certain of which are commonly owned with the instant
application, and each of which is herein incorporated by
5 reference in its entirety.

Oligonucleotides may also include nucleobase (often referred to in the art simply as "base") modifications or substitutions. As used herein, "unmodified" or "natural" nucleobases include the purine bases adenine (A) and
10 guanine (G), and the pyrimidine bases thymine (T), cytosine (C) and uracil (U). Modified nucleobases include other synthetic and natural nucleobases such as 5-methylcytosine (5-me-C), 5-hydroxymethyl cytosine, xanthine, hypoxanthine, 2-aminoadenine, 6-methyl and other alkyl derivatives of
15 adenine and guanine, 2-propyl and other alkyl derivatives of adenine and guanine, 2-thiouracil, 2-thiothymine and 2-thiocytosine, 5-halouracil and cytosine, 5-propynyl uracil and cytosine, 6-azo uracil, cytosine and thymine, 5-uracil (pseudouracil), 4-thiouracil, 8-halo, 8-amino, 8-thiol, 8-
20 thioalkyl, 8-hydroxyl and other 8-substituted adenines and guanines, 5-halo particularly 5-bromo, 5-trifluoromethyl and other 5-substituted uracils and cytosines, 7-methylguanine and 7-methyladenine, 8-azaguanine and 8-azaadenine, 7-deazaguanine and 7-deazaadenine and 3-
25 deazaguanine and 3-deazaadenine. Further nucleobases include those disclosed in United States Patent No.
3,687,808, those disclosed in *The Concise Encyclopedia Of Polymer Science And Engineering*, pages 858-859, Kroschwitz, J.I., ed. John Wiley & Sons, 1990, those disclosed by
30 Englisch et al., *Angewandte Chemie*, International Edition, 1991, 30, 613, and those disclosed by Sanghvi, Y.S., Chapter 15, *Antisense Research and Applications*, pages 289-302, Crooke, S.T. and Lebleu, B., ed., CRC Press, 1993. Certain of these nucleobases are particularly useful for

-17-

increasing the binding affinity of the oligomeric compounds of the invention. These include 5-substituted pyrimidines, 6-azapyrimidines and N-2, N-6 and O-6 substituted purines, including 2-aminopropyladenine, 5-propynyluracil and 5-
5 propynylcytosine. 5-methylcytosine substitutions have been shown to increase nucleic acid duplex stability by 0.6-1.2°C (Sanghvi, Y.S., Crooke, S.T. and Lebleu, B., eds., *Antisense Research and Applications*, CRC Press, Boca Raton, 1993, pp. 276-278) and are presently preferred base
10 substitutions, even more particularly when combined with 2'-O-methoxyethyl sugar modifications.

Representative United States patents that teach the preparation of certain of the above noted modified nucleobases as well as other modified nucleobases include, 15 but are not limited to, the above noted U.S. 3,687,808, as well as U.S.: 4,845,205; 5,130,302; 5,134,066; 5,175,273; 5,367,066; 5,432,272; 5,457,187; 5,459,255; 5,484,908; 5,502,177; 5,525,711; 5,552,540; 5,587,469; 5,594,121, 5,596,091; 5,614,617; and 5,681,941, certain of which are 20 commonly owned with the instant application, and each of which is herein incorporated by reference, and United States patent 5,750,692, which is commonly owned with the instant application and also herein incorporated by reference.

25 Another modification of the oligonucleotides of the invention involves chemically linking to the oligonucleotide one or more moieties or conjugates which enhance the activity, cellular distribution or cellular uptake of the oligonucleotide. Such moieties include but 30 are not limited to lipid moieties such as a cholesterol moiety (Letsinger et al., *Proc. Natl. Acad. Sci. USA*, 1989, 86, 6553-6556), cholic acid (Manoharan et al., *Bioorg. Med. Chem. Lett.*, 1994, 4, 1053-1060), a thioether, e.g., hexyl-S-tritylthiol (Manoharan et al., *Ann. N.Y. Acad. Sci.*,

-18-

- 1992, 660, 306-309; Manoharan et al., *Bioorg. Med. Chem. Lett.*, 1993, 3, 2765-2770), a thiocholesterol (Oberhauser et al., *Nucl. Acids Res.*, 1992, 20, 533-538), an aliphatic chain, e.g., dodecandiol or undecyl residues (Saison-
5 Behmoaras et al., *EMBO J.*, 1991, 10, 1111-1118; Kabanov et al., *FEBS Lett.*, 1990, 259, 327-330; Svinarchuk et al., *Biochimie*, 1993, 75, 49-54), a phospholipid, e.g., di-hexadecyl-rac-glycerol or triethylammonium 1,2-di-O-hexadecyl-rac-glycero-3-H-phosphonate (Manoharan et al.,
10 *Tetrahedron Lett.*, 1995, 36, 3651-3654; Shea et al., *Nucl. Acids Res.*, 1990, 18, 3777-3783), a polyamine or a polyethylene glycol chain (Manoharan et al., *Nucleosides & Nucleotides*, 1995, 14, 969-973), or adamantane acetic acid (Manoharan et al., *Tetrahedron Lett.*, 1995, 36, 3651-3654),
15 a palmityl moiety (Mishra et al., *Biochim. Biophys. Acta*, 1995, 1264, 229-237), or an octadecylamine or hexylamino-carbonyl-oxycholesterol moiety (Crooke et al., *J. Pharmacol. Exp. Ther.*, 1996, 277, 923-937).

Representative United States patents that teach the preparation of such oligonucleotide conjugates include, but are not limited to, U.S.: 4,828,979; 4,948,882; 5,218,105; 5,525,465; 5,541,313; 5,545,730; 5,552,538; 5,578,717; 5,580,731; 5,580,731; 5,591,584; 5,109,124; 5,118,802; 5,138,045; 5,414,077; 5,486,603; 5,512,439; 5,578,718; 25 5,608,046; 4,587,044; 4,605,735; 4,667,025; 4,762,779; 4,789,737; 4,824,941; 4,835,263; 4,876,335; 4,904,582; 4,958,013; 5,082,830; 5,112,963; 5,214,136; 5,082,830; 5,112,963; 5,214,136; 5,245,022; 5,254,469; 5,258,506; 5,262,536; 5,272,250; 5,292,873; 5,317,098; 5,371,241;
30 5,391,723; 5,416,203; 5,451,463; 5,510,475; 5,512,667; 5,514,785; 5,565,552; 5,567,810; 5,574,142; 5,585,481; 5,587,371; 5,595,726; 5,597,696; 5,599,923; 5,599,928 and 5,688,941, certain of which are commonly owned with the

-19-

instant application, and each of which is herein incorporated by reference.

It is not necessary for all positions in a given compound to be uniformly modified, and in fact more than 5 one of the aforementioned modifications may be incorporated in a single compound or even at a single nucleoside within an oligonucleotide. The present invention also includes antisense compounds which are chimeric compounds.

"Chimeric" antisense compounds or "chimeras," in the 10 context of this invention, are antisense compounds, particularly oligonucleotides, which contain two or more chemically distinct regions, each made up of at least one monomer unit, i.e., a nucleotide in the case of an oligonucleotide compound. These oligonucleotides typically 15 contain at least one region wherein the oligonucleotide is modified so as to confer upon the oligonucleotide increased resistance to nuclease degradation, increased cellular uptake, and/or increased binding affinity for the target nucleic acid. An additional region of the oligonucleotide 20 may serve as a substrate for enzymes capable of cleaving RNA:DNA or RNA:RNA hybrids. By way of example, RNase H is a cellular endonuclease which cleaves the RNA strand of an RNA:DNA duplex. Activation of RNase H, therefore, results in cleavage of the RNA target, thereby greatly enhancing 25 the efficiency of oligonucleotide inhibition of gene expression. Consequently, comparable results can often be obtained with shorter oligonucleotides when chimeric oligonucleotides are used, compared to phosphorothioate deoxyoligonucleotides hybridizing to the same target 30 region. Cleavage of the RNA target can be routinely detected by gel electrophoresis and, if necessary, associated nucleic acid hybridization techniques known in the art.

Chimeric antisense compounds of the invention may be 35 formed as composite structures of two or more

-20-

oligonucleotides, modified oligonucleotides, oligonucleosides and/or oligonucleotide mimetics as described above. Such compounds have also been referred to in the art as hybrids or gapmers. Representative United States patents that teach the preparation of such hybrid structures include, but are not limited to, U.S.: 5,013,830; 5,149,797; 5,220,007; 5,256,775; 5,366,878; 5,403,711; 5,491,133; 5,565,350; 5,623,065; 5,652,355; 5,652,356; and 5,700,922, certain of which are commonly owned with the instant application, and each of which is herein incorporated by reference in its entirety.

The antisense compounds used in accordance with this invention may be conveniently and routinely made through the well-known technique of solid phase synthesis.

Equipment for such synthesis is sold by several vendors including, for example, Applied Biosystems (Foster City, CA). Any other means for such synthesis known in the art may additionally or alternatively be employed. It is well known to use similar techniques to prepare oligonucleotides such as the phosphorothioates and alkylated derivatives.

The antisense compounds of the invention are synthesized in vitro and do not include antisense compositions of biological origin, or genetic vector constructs designed to direct the in vivo synthesis of antisense molecules.

The compounds of the invention may also be admixed, encapsulated, conjugated or otherwise associated with other molecules, molecule structures or mixtures of compounds, as for example, liposomes, receptor targeted molecules, oral, rectal, topical or other formulations, for assisting in uptake, distribution and/or absorption. Representative United States patents that teach the preparation of such uptake, distribution and/or absorption assisting formulations include, but are not limited to, U.S.: 5,108,921; 5,354,844; 5,416,016; 5,459,127; 5,521,291;

-21-

- 5,543,158; 5,547,932; 5,583,020; 5,591,721; 4,426,330;
4,534,899; 5,013,556; 5,108,921; 5,213,804; 5,227,170;
5,264,221; 5,356,633; 5,395,619; 5,416,016; 5,417,978;
5,462,854; 5,469,854; 5,512,295; 5,527,528; 5,534,259;
5 5,543,152; 5,556,948; 5,580,575; and 5,595,756, each of
which is herein incorporated by reference.

- The antisense compounds of the invention encompass any pharmaceutically acceptable salts, esters, or salts of such esters, or any other compound which, upon
10 administration to an animal including a human, is capable of providing (directly or indirectly) the biologically active metabolite or residue thereof. Accordingly, for example, the disclosure is also drawn to prodrugs and pharmaceutically acceptable salts of the compounds of the
15 invention, pharmaceutically acceptable salts of such prodrugs, and other bioequivalents.

- The term "prodrug" indicates a therapeutic agent that is prepared in an inactive form that is converted to an active form (i.e., drug) within the body or cells thereof
20 by the action of endogenous enzymes or other chemicals and/or conditions. In particular, prodrug versions of the oligonucleotides of the invention are prepared as SATE [(S-acetyl-2-thioethyl) phosphate] derivatives according to the methods disclosed in WO 93/24510 to Gosselin et al.,
25 published December 9, 1993 or in WO 94/26764 to Imbach et al.

- The term "pharmaceutically acceptable salts" refers to physiologically and pharmaceutically acceptable salts of the compounds of the invention: i.e., salts that retain the
30 desired biological activity of the parent compound and do not impart undesired toxicological effects thereto.

- Pharmaceutically acceptable base addition salts are formed with metals or amines, such as alkali and alkaline earth metals or organic amines. Examples of metals used as
35 cations are sodium, potassium, magnesium, calcium, and the

-22-

like. Examples of suitable amines are N,N'-dibenzylethylenediamine, chloroprocaine, choline, diethanolamine, dicyclohexylamine, ethylenediamine, N-methylglucamine, and procaine (see, for example, Berge et al., "Pharmaceutical Salts," *J. of Pharma Sci.*, 1977, 66, 1-19). The base addition salts of said acidic compounds are prepared by contacting the free acid form with a sufficient amount of the desired base to produce the salt in the conventional manner. The free acid form may be regenerated by contacting the salt form with an acid and isolating the free acid in the conventional manner. The free acid forms differ from their respective salt forms somewhat in certain physical properties such as solubility in polar solvents, but otherwise the salts are equivalent to their respective free acid for purposes of the present invention. As used herein, a "pharmaceutical addition salt" includes a pharmaceutically acceptable salt of an acid form of one of the components of the compositions of the invention. These include organic or inorganic acid salts of the amines. Preferred acid salts are the hydrochlorides, acetates, salicylates, nitrates and phosphates. Other suitable pharmaceutically acceptable salts are well known to those skilled in the art and include basic salts of a variety of inorganic and organic acids, such as, for example, with inorganic acids, such as for example hydrochloric acid, hydrobromic acid, sulfuric acid or phosphoric acid; with organic carboxylic, sulfonic, sulfo or phospho acids or N-substituted sulfamic acids, for example acetic acid, propionic acid, glycolic acid, succinic acid, maleic acid, hydroxymaleic acid, methylmaleic acid, fumaric acid, malic acid, tartaric acid, lactic acid, oxalic acid, gluconic acid, glucaric acid, glucuronic acid, citric acid, benzoic acid, cinnamic acid, mandelic acid, salicylic acid, 4-aminosalicylic acid, 2-phenoxybenzoic acid, 2-acetoxybenzoic acid, embonic acid,

-23-

nicotinic acid or isonicotinic acid; and with amino acids, such as the 20 alpha-amino acids involved in the synthesis of proteins in nature, for example glutamic acid or aspartic acid, and also with phenylacetic acid,

5 methanesulfonic acid, ethanesulfonic acid, 2-hydroxyethanesulfonic acid, ethane-1,2-disulfonic acid, benzenesulfonic acid, 4-methylbenzenesulfoic acid, naphthalene-2-sulfonic acid, naphthalene-1,5-disulfonic acid, 2- or 3-phosphoglycerate, glucose-6-phosphate,

10 N-cyclohexylsulfamic acid (with the formation of cyclamates), or with other acid organic compounds, such as ascorbic acid. Pharmaceutically acceptable salts of compounds may also be prepared with a pharmaceutically acceptable cation. Suitable pharmaceutically acceptable

15 cations are well known to those skilled in the art and include alkaline, alkaline earth, ammonium and quaternary ammonium cations. Carbonates or hydrogen carbonates are also possible.

For oligonucleotides, preferred examples of pharmaceutically acceptable salts include but are not limited to (a) salts formed with cations such as sodium, potassium, ammonium, magnesium, calcium, polyamines such as spermine and spermidine, etc.; (b) acid addition salts formed with inorganic acids, for example hydrochloric acid,

25 hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid and the like; (c) salts formed with organic acids such as, for example, acetic acid, oxalic acid, tartaric acid, succinic acid, maleic acid, fumaric acid, gluconic acid, citric acid, malic acid, ascorbic acid, benzoic acid,

30 tannic acid, palmitic acid, alginic acid, polyglutamic acid, naphthalenesulfonic acid, methanesulfonic acid, p-toluenesulfonic acid, naphthalenedisulfonic acid, polygalacturonic acid, and the like; and (d) salts formed from elemental anions such as chlorine, bromine, and

35 iodine.

-24-

The antisense compounds of the present invention can be utilized for diagnostics, therapeutics, prophylaxis and as research reagents and kits. For therapeutics, an animal, preferably a human, suspected of having a disease or disorder which can be treated by modulating the expression of Protein kinase C-theta is treated by administering antisense compounds in accordance with this invention. The compounds of the invention can be utilized in pharmaceutical compositions by adding an effective amount of an antisense compound to a suitable pharmaceutically acceptable diluent or carrier. Use of the antisense compounds and methods of the invention may also be useful prophylactically, e.g., to prevent or delay infection, inflammation or tumor formation, for example.

The antisense compounds of the invention are useful for research and diagnostics, because these compounds hybridize to nucleic acids encoding Protein kinase C-theta, enabling sandwich and other assays to easily be constructed to exploit this fact. Hybridization of the antisense oligonucleotides of the invention with a nucleic acid encoding Protein kinase C-theta can be detected by means known in the art. Such means may include conjugation of an enzyme to the oligonucleotide, radiolabelling of the oligonucleotide or any other suitable detection means.

Kits using such detection means for detecting the level of Protein kinase C-theta in a sample may also be prepared.

The present invention also includes pharmaceutical compositions and formulations which include the antisense compounds of the invention. The pharmaceutical compositions of the present invention may be administered in a number of ways depending upon whether local or systemic treatment is desired and upon the area to be treated. Administration may be topical (including ophthalmic and to mucous membranes including vaginal and rectal delivery), pulmonary, e.g., by inhalation or

-25-

- insufflation of powders or aerosols, including by nebulizer; intratracheal, intranasal, epidermal and transdermal), oral or parenteral. Parenteral administration includes intravenous, intraarterial,
5 subcutaneous, intraperitoneal or intramuscular injection or infusion; or intracranial, e.g., intrathecal or intraventricular, administration. Oligonucleotides with at least one 2'-O-methoxyethyl modification are believed to be particularly useful for oral administration.

- 10 Pharmaceutical compositions and formulations for topical administration may include transdermal patches, ointments, lotions, creams, gels, drops, suppositories, sprays, liquids and powders. Conventional pharmaceutical carriers, aqueous, powder or oily bases, thickeners and the
15 like may be necessary or desirable. Coated condoms, gloves and the like may also be useful.

- Compositions and formulations for oral administration include powders or granules, suspensions or solutions in water or non-aqueous media, capsules, sachets or tablets.
20 Thickeners, flavoring agents, diluents, emulsifiers, dispersing aids or binders may be desirable.

- Compositions and formulations for parenteral, intrathecal or intraventricular administration may include sterile aqueous solutions which may also contain buffers,
25 diluents and other suitable additives such as, but not limited to, penetration enhancers, carrier compounds and other pharmaceutically acceptable carriers or excipients.

- Pharmaceutical compositions of the present invention include, but are not limited to, solutions, emulsions, and
30 liposome-containing formulations. These compositions may be generated from a variety of components that include, but are not limited to, preformed liquids, self-emulsifying solids and self-emulsifying semisolids.

- The pharmaceutical formulations of the present
35 invention, which may conveniently be presented in unit

-26-

dosage form, may be prepared according to conventional techniques well known in the pharmaceutical industry. Such techniques include the step of bringing into association the active ingredients with the pharmaceutical carrier(s) 5 or excipient(s). In general the formulations are prepared by uniformly and intimately bringing into association the active ingredients with liquid carriers or finely divided solid carriers or both, and then, if necessary, shaping the product.

10 The compositions of the present invention may be formulated into any of many possible dosage forms such as, but not limited to, tablets, capsules, liquid syrups, soft gels, suppositories, and enemas. The compositions of the present invention may also be formulated as suspensions in 15 aqueous, non-aqueous or mixed media. Aqueous suspensions may further contain substances which increase the viscosity of the suspension including, for example, sodium carboxymethylcellulose, sorbitol and/or dextran. The suspension may also contain stabilizers.

20 In one embodiment of the present invention the pharmaceutical compositions may be formulated and used as foams. Pharmaceutical foams include formulations such as, but not limited to, emulsions, microemulsions, creams, jellies and liposomes. While basically similar in nature 25 these formulations vary in the components and the consistency of the final product. The preparation of such compositions and formulations is generally known to those skilled in the pharmaceutical and formulation arts and may be applied to the formulation of the compositions of the 30 present invention.

Emulsions

The compositions of the present invention may be prepared and formulated as emulsions. Emulsions are 35 typically heterogenous systems of one liquid dispersed in

-27-

another in the form of droplets usually exceeding 0.1 μm in diameter. (Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199; Rosoff, in 5 *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., Volume 1, p. 245; Block in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 2, p. 335; Higuchi et al., in 10 *Remington's Pharmaceutical Sciences*, Mack Publishing Co., Easton, PA, 1985, p. 301). Emulsions are often biphasic systems comprising of two immiscible liquid phases intimately mixed and dispersed with each other. In general, emulsions may be either water-in-oil (w/o) or of 15 the oil-in-water (o/w) variety. When an aqueous phase is finely divided into and dispersed as minute droplets into a bulk oily phase the resulting composition is called a water-in-oil (w/o) emulsion. Alternatively, when an oily phase is finely divided into and dispersed as minute 20 droplets into a bulk aqueous phase the resulting composition is called an oil-in-water (o/w) emulsion. Emulsions may contain additional components in addition to the dispersed phases and the active drug which may be present as a solution in either the aqueous phase, oily 25 phase or itself as a separate phase. Pharmaceutical excipients such as emulsifiers, stabilizers, dyes, and anti-oxidants may also be present in emulsions as needed. Pharmaceutical emulsions may also be multiple emulsions that are comprised of more than two phases such as, for 30 example, in the case of oil-in-water-in-oil (o/w/o) and water-in-oil-in-water (w/o/w) emulsions. Such complex formulations often provide certain advantages that simple binary emulsions do not. Multiple emulsions in which individual oil droplets of an o/w emulsion enclose small

-28-

water droplets constitute a w/o/w emulsion. Likewise a system of oil droplets enclosed in globules of water stabilized in an oily continuous provides an o/w/o emulsion.

- 5 Emulsions are characterized by little or no thermodynamic stability. Often, the dispersed or discontinuous phase of the emulsion is well dispersed into the external or continuous phase and maintained in this form through the means of emulsifiers or the viscosity of
- 10 the formulation. Either of the phases of the emulsion may be a semisolid or a solid, as is the case of emulsion-style ointment bases and creams. Other means of stabilizing emulsions entail the use of emulsifiers that may be incorporated into either phase of the emulsion.
- 15 Emulsifiers may broadly be classified into four categories: synthetic surfactants, naturally occurring emulsifiers, absorption bases, and finely dispersed solids (Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Bunker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume
- 20 1, p. 199).

Synthetic surfactants, also known as surface active agents, have found wide applicability in the formulation of emulsions and have been reviewed in the literature (Rieger, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Bunker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 285; Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Bunker (Eds.), Marcel Dekker, Inc., New York, N.Y., 1988, volume 1, p. 199). Surfactants are typically amphiphilic and comprise a hydrophilic and a hydrophobic portion. The ratio of the hydrophilic to the hydrophobic nature of the surfactant has been termed the hydrophile/lipophile balance (HLB) and is a valuable tool in categorizing and selecting surfactants in the preparation of formulations. Surfactants may be classified

35 into different classes based on the nature of the

-29-

hydrophilic group: nonionic, anionic, cationic and amphoteric (Rieger, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Bunker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 285).

5 Naturally occurring emulsifiers used in emulsion formulations include lanolin, beeswax, phosphatides, lecithin and acacia. Absorption bases possess hydrophilic properties such that they can soak up water to form w/o emulsions yet retain their semisolid consistencies, such as
10 anhydrous lanolin and hydrophilic petrolatum. Finely divided solids have also been used as good emulsifiers especially in combination with surfactants and in viscous preparations. These include polar inorganic solids, such as heavy metal hydroxides, nonswelling clays such as
15 bentonite, attapulgite, hectorite, kaolin, montmorillonite, colloidal aluminum silicate and colloidal magnesium aluminum silicate, pigments and nonpolar solids such as carbon or glyceryl tristearate.

A large variety of non-emulsifying materials are also
20 included in emulsion formulations and contribute to the properties of emulsions. These include fats, oils, waxes, fatty acids, fatty alcohols, fatty esters, humectants, hydrophilic colloids, preservatives and antioxidants (Block, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger
25 and Bunker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 335; Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Bunker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199).

Hydrophilic colloids or hydrocolloids include
30 naturally occurring gums and synthetic polymers such as polysaccharides (for example, acacia, agar, alginic acid, carrageenan, guar gum, karaya gum, and tragacanth), cellulose derivatives (for example, carboxymethylcellulose and carboxypropylcellulose), and synthetic polymers (for
35 example, carbomers, cellulose ethers, and carboxyvinyl

-30-

polymers). These disperse or swell in water to form colloidal solutions that stabilize emulsions by forming strong interfacial films around the dispersed-phase droplets and by increasing the viscosity of the external 5 phase.

Since emulsions often contain a number of ingredients such as carbohydrates, proteins, sterols and phosphatides that may readily support the growth of microbes, these formulations often incorporate preservatives. Commonly 10 used preservatives included in emulsion formulations include methyl paraben, propyl paraben, quaternary ammonium salts, benzalkonium chloride, esters of p-hydroxybenzoic acid, and boric acid. Antioxidants are also commonly added to emulsion formulations to prevent deterioration of the 15 formulation. Antioxidants used may be free radical scavengers such as tocopherols, alkyl gallates, butylated hydroxyanisole, butylated hydroxytoluene, or reducing agents such as ascorbic acid and sodium metabisulfite, and antioxidant synergists such as citric acid, tartaric acid, 20 and lecithin.

The application of emulsion formulations via dermatological, oral and parenteral routes and methods for their manufacture have been reviewed in the literature (Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger 25 and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199). Emulsion formulations for oral delivery have been very widely used because of reasons of ease of formulation, efficacy from an absorption and bioavailability standpoint. (Rosoff, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 245; Idson, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger 30 and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 199). Mineral-oil base laxatives, oil- 35 soluble vitamins and high fat nutritive preparations are

-31-

among the materials that have commonly been administered orally as o/w emulsions.

In one embodiment of the present invention, the compositions of oligonucleotides and nucleic acids are 5 formulated as microemulsions. A microemulsion may be defined as a system of water, oil and amphiphile which is a single optically isotropic and thermodynamically stable liquid solution (Rosoff, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Bunker (Eds.), 1988, Marcel Dekker, 10 Inc., New York, N.Y., volume 1, p. 245). Typically microemulsions are systems that are prepared by first dispersing an oil in an aqueous surfactant solution and then adding a sufficient amount of a fourth component, generally an intermediate chain-length alcohol to form a 15 transparent system. Therefore, microemulsions have also been described as thermodynamically stable, isotropically clear dispersions of two immiscible liquids that are stabilized by interfacial films of surface-active molecules (Leung and Shah, in: *Controlled Release of Drugs: Polymers and Aggregate Systems*, Rosoff, M., Ed., 1989, VCH Publishers, New York, pages 185-215). Microemulsions commonly are prepared via a combination of three to five components that include oil, water, surfactant, cosurfactant and electrolyte. Whether the microemulsion is 20 25 of the water-in-oil (w/o) or an oil-in-water (o/w) type is dependent on the properties of the oil and surfactant used and on the structure and geometric packing of the polar heads and hydrocarbon tails of the surfactant molecules (Schott, in *Remington's Pharmaceutical Sciences*, Mack Publishing Co., Easton, PA, 1985, p. 271).

The phenomenological approach utilizing phase diagrams has been extensively studied and has yielded a comprehensive knowledge, to one skilled in the art, of how to formulate microemulsions (Rosoff, in *Pharmaceutical*

-32-

Dosage Forms, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York, N.Y., volume 1, p. 245; Block, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988, Marcel Dekker, Inc., New York,

5 N.Y., volume 1, p. 335). Compared to conventional emulsions, microemulsions offer the advantage of solubilizing water-insoluble drugs in a formulation of thermodynamically stable droplets that are formed spontaneously.

10 Surfactants used in the preparation of microemulsions include, but are not limited to, ionic surfactants, non-ionic surfactants, Brij 96, polyoxyethylene oleyl ethers, polyglycerol fatty acid esters, tetraglycerol monolaurate (ML310), tetraglycerol monooleate (MO310), hexaglycerol 15 monooleate (PO310), hexaglycerol pentaoleate (PO500), decaglycerol monocaprate (MCA750), decaglycerol monooleate (MO750), decaglycerol sequioleate (SO750), decaglycerol decaoleate (DAO750), alone or in combination with cosurfactants. The cosurfactant, usually a short-chain 20 alcohol such as ethanol, 1-propanol, and 1-butanol, serves to increase the interfacial fluidity by penetrating into the surfactant film and consequently creating a disordered film because of the void space generated among surfactant molecules. Microemulsions may, however, be prepared 25 without the use of cosurfactants and alcohol-free self-emulsifying microemulsion systems are known in the art. The aqueous phase may typically be, but is not limited to, water, an aqueous solution of the drug, glycerol, PEG300, PEG400, polyglycerols, propylene glycols, and derivatives 30 of ethylene glycol. The oil phase may include, but is not limited to, materials such as Captex 300, Captex 355, Capmul MCM, fatty acid esters, medium chain (C8-C12) mono, di, and tri-glycerides, polyoxyethylated glyceryl fatty acid esters, fatty alcohols, polyglycolized glycerides,

- 33 -

saturated polyglycolized C8-C10 glycerides, vegetable oils and silicone oil.

Microemulsions are particularly of interest from the standpoint of drug solubilization and the enhanced absorption of drugs. Lipid based microemulsions (both o/w and w/o) have been proposed to enhance the oral bioavailability of drugs, including peptides (Constantinides et al., *Pharmaceutical Research*, 1994, 11, 1385-1390; Ritschel, *Meth. Find. Exp. Clin. Pharmacol.*, 1993, 13, 205). Microemulsions afford advantages of improved drug solubilization, protection of drug from enzymatic hydrolysis, possible enhancement of drug absorption due to surfactant-induced alterations in membrane fluidity and permeability, ease of preparation, ease of oral administration over solid dosage forms, improved clinical potency, and decreased toxicity (Constantinides et al., *Pharmaceutical Research*, 1994, 11, 1385; Ho et al., *J. Pharm. Sci.*, 1996, 85, 138-143). Often microemulsions may form spontaneously when their components are brought together at ambient temperature. This may be particularly advantageous when formulating thermolabile drugs, peptides or oligonucleotides. Microemulsions have also been effective in the transdermal delivery of active components in both cosmetic and pharmaceutical applications. It is expected that the microemulsion compositions and formulations of the present invention will facilitate the increased systemic absorption of oligonucleotides and nucleic acids from the gastrointestinal tract, as well as improve the local cellular uptake of oligonucleotides and nucleic acids within the gastrointestinal tract, vagina, buccal cavity and other areas of administration.

Microemulsions of the present invention may also contain additional components and additives such as

-34-

sorbitan monostearate (Grill 3), Labrasol, and penetration enhancers to improve the properties of the formulation and to enhance the absorption of the oligonucleotides and nucleic acids of the present invention. Penetration
5 enhancers used in the microemulsions of the present invention may be classified as belonging to one of five broad categories - surfactants, fatty acids, bile salts, chelating agents, and non-chelating non-surfactants (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*,
10 1991, p. 92). Each of these classes has been discussed above.

Liposomes

There are many organized surfactant structures
15 besides microemulsions that have been studied and used for the formulation of drugs. These include monolayers, micelles, bilayers and vesicles. Vesicles, such as liposomes, have attracted great interest because of their specificity and the duration of action they offer from the
20 standpoint of drug delivery. As used in the present invention, the term "liposome" means a vesicle composed of amphiphilic lipids arranged in a spherical bilayer or bilayers.

Liposomes are unilamellar or multilamellar vesicles
25 which have a membrane formed from a lipophilic material and an aqueous interior. The aqueous portion contains the composition to be delivered. Cationic liposomes possess the advantage of being able to fuse to the cell wall. Non-cationic liposomes, although not able to fuse as
30 efficiently with the cell wall, are taken up by macrophages *in vivo*.

In order to cross intact mammalian skin, lipid vesicles must pass through a series of fine pores, each with a diameter less than 50 nm, under the influence of a
35 suitable transdermal gradient. Therefore, it is desirable

-35-

to use a liposome which is highly deformable and able to pass through such fine pores.

Further advantages of liposomes include; liposomes obtained from natural phospholipids are biocompatible and
5 biodegradable; liposomes can incorporate a wide range of water and lipid soluble drugs; liposomes can protect encapsulated drugs in their internal compartments from metabolism and degradation (Rosoff, in *Pharmaceutical Dosage Forms*, Lieberman, Rieger and Banker (Eds.), 1988,
10 Marcel Dekker, Inc., New York, N.Y., volume 1, p. 245). Important considerations in the preparation of liposome formulations are the lipid surface charge, vesicle size and the aqueous volume of the liposomes.

Liposomes are useful for the transfer and delivery
15 of active ingredients to the site of action. Because the liposomal membrane is structurally similar to biological membranes, when liposomes are applied to a tissue, the liposomes start to merge with the cellular membranes. As the merging of the liposome and cell progresses, the
20 liposomal contents are emptied into the cell where the active agent may act.

Liposomal formulations have been the focus of extensive investigation as the mode of delivery for many drugs. There is growing evidence that for topical
25 administration, liposomes present several advantages over other formulations. Such advantages include reduced side-effects related to high systemic absorption of the administered drug, increased accumulation of the administered drug at the desired target, and the ability to
30 administer a wide variety of drugs, both hydrophilic and hydrophobic, into the skin.

Several reports have detailed the ability of liposomes to deliver agents including high-molecular weight DNA into the skin. Compounds including analgesics,
35 antibodies, hormones and high-molecular weight DNAs have

-36-

been administered to the skin. The majority of applications resulted in the targeting of the upper epidermis.

Liposomes fall into two broad classes. Cationic 5 liposomes are positively charged liposomes which interact with the negatively charged DNA molecules to form a stable complex. The positively charged DNA/liposome complex binds to the negatively charged cell surface and is internalized to the acidic pH within the endosome, 10 the liposomes are ruptured, releasing their contents into the cell cytoplasm (Wang et al., *Biochem. Biophys. Res. Commun.*, 1987, 147, 980-985).

Liposomes which are pH-sensitive or negatively-charged, entrap DNA rather than complex with it. 15 Since both the DNA and the lipid are similarly charged, repulsion rather than complex formation occurs. Nevertheless, some DNA is entrapped within the aqueous interior of these liposomes. pH-sensitive liposomes have been used to deliver DNA encoding the thymidine kinase gene 20 to cell monolayers in culture. Expression of the exogenous gene was detected in the target cells (Zhou et al., *Journal of Controlled Release*, 1992, 19, 269-274).

One major type of liposomal composition includes phospholipids other than naturally-derived 25 phosphatidylcholine. Neutral liposome compositions, for example, can be formed from dimyristoyl phosphatidylcholine (DMPC) or dipalmitoyl phosphatidylcholine (DPPC). Anionic liposome compositions generally are formed from dimyristoyl phosphatidylglycerol, while anionic fusogenic liposomes are 30 formed primarily from dioleoyl phosphatidylethanolamine (DOPE). Another type of liposomal composition is formed from phosphatidylcholine (PC) such as, for example, soybean PC, and egg PC. Another type is formed from mixtures of phospholipid and/or phosphatidylcholine and/or cholesterol.

-37-

Several studies have assessed the topical delivery of liposomal drug formulations to the skin. Application of liposomes containing interferon to guinea pig skin resulted in a reduction of skin herpes sores while delivery of 5 interferon via other means (e.g. as a solution or as an emulsion) were ineffective (Weiner et al., *Journal of Drug Targeting*, 1992, 2, 405-410). Further, an additional study tested the efficacy of interferon administered as part of a 10 liposomal formulation to the administration of interferon using an aqueous system, and concluded that the liposomal formulation was superior to aqueous administration (du Plessis et al., *Antiviral Research*, 1992, 18, 259-265).

Non-ionic liposomal systems have also been examined to determine their utility in the delivery of drugs to the 15 skin, in particular systems comprising non-ionic surfactant and cholesterol. Non-ionic liposomal formulations comprising Novosome™ I (glyceryl dilaurate/cholesterol/polyoxyethylene-10-stearyl ether) and Novosome™ II (glyceryl distearate/ 20 cholesterol/polyoxyethylene-10-stearyl ether) were used to deliver cyclosporin-A into the dermis of mouse skin. Results indicated that such non-ionic liposomal systems were effective in facilitating the deposition of cyclosporin-A into different layers of the skin (Hu et al. 25 *S.T.P. Pharma. Sci.*, 1994, 4, 6, 466).

Liposomes also include "sterically stabilized" liposomes, a term which, as used herein, refers to liposomes comprising one or more specialized lipids that, when incorporated into liposomes, result in enhanced 30 circulation lifetimes relative to liposomes lacking such specialized lipids. Examples of sterically stabilized liposomes are those in which part of the vesicle-forming lipid portion of the liposome (A) comprises one or more glycolipids, such as monosialoganglioside G_{M1}, or (B) is 35 derivatized with one or more hydrophilic polymers, such as

-38-

a polyethylene glycol (PEG) moiety. While not wishing to be bound by any particular theory, it is thought in the art that, at least for sterically stabilized liposomes containing gangliosides, sphingomyelin, or PEG-derivatized 5 lipids, the enhanced circulation half-life of these sterically stabilized liposomes derives from a reduced uptake into cells of the reticuloendothelial system (RES) (Allen et al., *FEBS Letters*, 1987, 223, 42; Wu et al., *Cancer Research*, 1993, 53, 3765). Various 10 liposomes comprising one or more glycolipids are known in the art. Papahadjopoulos et al. (*Ann. N.Y. Acad. Sci.*, 1987, 507, 64) reported the ability of monosialoganglioside G_{M1}, galactocerebroside sulfate and phosphatidylinositol to improve blood half-lives of 15 liposomes. These findings were expounded upon by Gabizon et al. (*Proc. Natl. Acad. Sci. U.S.A.*, 1988, 85, 6949). U.S. Patent No. 4,837,028 and WO 88/04924, both to Allen et al., disclose liposomes comprising (1) sphingomyelin and (2) the ganglioside G_{M1} or a galactocerebroside sulfate 20 ester. U.S. Patent No. 5,543,152 (Webb et al.) discloses liposomes comprising sphingomyelin. Liposomes comprising 1,2-sn-dimyristoylphosphatidylcholine are disclosed in WO 97/13499 (Lim et al.).

Many liposomes comprising lipids derivatized with one 25 or more hydrophilic polymers, and methods of preparation thereof, are known in the art. Sunamoto et al. (*Bull. Chem. Soc. Jpn.*, 1980, 53, 2778) described liposomes comprising a nonionic detergent, 2C₁₂15G, that contains a PEG moiety. Illum et al. (*FEBS Lett.*, 1984, 167, 79) noted 30 that hydrophilic coating of polystyrene particles with polymeric glycals results in significantly enhanced blood half-lives. Synthetic phospholipids modified by the attachment of carboxylic groups of polyalkylene glycals (e.g., PEG) are described by Sears (U.S. Patent Nos.

-39-

- 4,426,330 and 4,534,899). Klibanov et al. (*FEBS Lett.*, 1990, 268, 235) described experiments demonstrating that liposomes comprising phosphatidylethanolamine (PE) derivatized with PEG or PEG stearate have significant increases in blood circulation half-lives. Blume et al. (*Biochimica et Biophysica Acta*, 1990, 1029, 91) extended such observations to other PEG-derivatized phospholipids, e.g., DSPE-PEG, formed from the combination of distearoylphosphatidylethanolamine (DSPE) and PEG.
- Liposomes having covalently bound PEG moieties on their external surface are described in European Patent No. EP 0 445 131 B1 and WO 90/04384 to Fisher. Liposome compositions containing 1-20 mole percent of PE derivatized with PEG, and methods of use thereof, are described by Woodle et al. (U.S. Patent Nos. 5,013,556 and 5,356,633) and Martin et al. (U.S. Patent No. 5,213,804 and European Patent No. EP 0 496 813 B1). Liposomes comprising a number of other lipid-polymer conjugates are disclosed in WO 91/05545 and U.S. Patent No. 5,225,212 (both to Martin et al.) and in WO 94/20073 (Zalipsky et al.). Liposomes comprising PEG-modified ceramide lipids are described in WO 96/10391 (Choi et al.). U.S. Patent Nos. 5,540,935 (Miyazaki et al.) and 5,556,948 (Tagawa et al.) describe PEG-containing liposomes that can be further derivatized with functional moieties on their surfaces.

A limited number of liposomes comprising nucleic acids are known in the art. WO 96/40062 to Thierry et al. discloses methods for encapsulating high molecular weight nucleic acids in liposomes. U.S. Patent No. 5,264,221 to Tagawa et al. discloses protein-bonded liposomes and asserts that the contents of such liposomes may include an antisense RNA. U.S. Patent No. 5,665,710 to Rahman et al. describes certain methods of encapsulating oligodeoxynucleotides in liposomes. WO 97/04787 to Love et

-40-

a1. discloses liposomes comprising antisense oligonucleotides targeted to the raf gene.

Transfersomes are yet another type of liposomes, and are highly deformable lipid aggregates which are attractive 5 candidates for drug delivery vehicles. Transfersomes may be described as lipid droplets which are so highly deformable that they are easily able to penetrate through pores which are smaller than the droplet. Transfersomes are adaptable to the environment in which they are used, 10 e.g. they are self-optimizing (adaptive to the shape of pores in the skin), self-repairing, frequently reach their targets without fragmenting, and often self-loading. To make transfersomes it is possible to add surface edge-activators, usually surfactants, to a standard liposomal 15 composition. Transfersomes have been used to deliver serum albumin to the skin. The transfersome-mediated delivery of serum albumin has been shown to be as effective as subcutaneous injection of a solution containing serum albumin.

20 Surfactants find wide application in formulations such as emulsions (including microemulsions) and liposomes. The most common way of classifying and ranking the properties of the many different types of surfactants, both natural and synthetic, is by the use of the 25 hydrophile/lipophile balance (HLB). The nature of the hydrophilic group (also known as the "head") provides the most useful means for categorizing the different surfactants used in formulations (Rieger, in *Pharmaceutical Dosage Forms*, Marcel Dekker, Inc., New York, NY, 1988, p. 30 285).

If the surfactant molecule is not ionized, it is classified as a nonionic surfactant. Nonionic surfactants find wide application in pharmaceutical and cosmetic products and are usable over a wide range of pH values. In 35 general their HLB values range from 2 to about 18 depending

-41-

on their structure. Nonionic surfactants include nonionic esters such as ethylene glycol esters, propylene glycol esters, glyceryl esters, polyglyceryl esters, sorbitan esters, sucrose esters, and ethoxylated esters. Nonionic 5 alkanolamides and ethers such as fatty alcohol ethoxylates, propoxylated alcohols, and ethoxylated/propoxylated block polymers are also included in this class. The polyoxyethylene surfactants are the most popular members of the nonionic surfactant class.

10 If the surfactant molecule carries a negative charge when it is dissolved or dispersed in water, the surfactant is classified as anionic. Anionic surfactants include carboxylates such as soaps, acyl lactylates, acyl amides of amino acids, esters of sulfuric acid such as alkyl sulfates 15 and ethoxylated alkyl sulfates, sulfonates such as alkyl benzene sulfonates, acyl isethionates, acyl taurates and sulfosuccinates, and phosphates. The most important members of the anionic surfactant class are the alkyl sulfates and the soaps.

20 If the surfactant molecule carries a positive charge when it is dissolved or dispersed in water, the surfactant is classified as cationic. Cationic surfactants include quaternary ammonium salts and ethoxylated amines. The quaternary ammonium salts are the most used members of this 25 class.

If the surfactant molecule has the ability to carry either a positive or negative charge, the surfactant is classified as amphoteric. Amphoteric surfactants include acrylic acid derivatives, substituted alkylamides, N- 30 alkylbetaines and phosphatides.

The use of surfactants in drug products, formulations and in emulsions has been reviewed (Rieger, in *Pharmaceutical Dosage Forms*, Marcel Dekker, Inc., New York, NY, 1988, p. 285).

-42-

Penetration Enhancers

In one embodiment, the present invention employs various penetration enhancers to effect the efficient delivery of nucleic acids, particularly oligonucleotides, 5 to the skin of animals. Most drugs are present in solution in both ionized and nonionized forms. However, usually only lipid soluble or lipophilic drugs readily cross cell membranes. It has been discovered that even non-lipophilic drugs may cross cell membranes if the membrane to be 10 crossed is treated with a penetration enhancer. In addition to aiding the diffusion of non-lipophilic drugs across cell membranes, penetration enhancers also enhance the permeability of lipophilic drugs.

Penetration enhancers may be classified as belonging 15 to one of five broad categories, i.e., surfactants, fatty acids, bile salts, chelating agents, and non-chelating non-surfactants (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, p.92). Each of the above mentioned classes of penetration enhancers are described 20 below in greater detail.

Surfactants: In connection with the present invention, surfactants (or "surface-active agents") are chemical entities which, when dissolved in an aqueous solution, reduce the surface tension of the solution or the 25 interfacial tension between the aqueous solution and another liquid, with the result that absorption of oligonucleotides through the mucosa is enhanced. In addition to bile salts and fatty acids, these penetration enhancers include, for example, sodium lauryl sulfate, 30 polyoxyethylene-9-lauryl ether and polyoxyethylene-20-cetyl ether) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, p.92); and perfluorochemical emulsions, such as FC-43. Takahashi et al., *J. Pharm. Pharmacol.*, 1988, 40, 252).

-43-

Fatty acids: Various fatty acids and their derivatives which act as penetration enhancers include, for example, oleic acid, lauric acid, capric acid (n-decanoic acid), myristic acid, palmitic acid, stearic acid, linoleic acid, linolenic acid, dicaprate, tricaprate, monoolein (1-monooleoyl-rac-glycerol), dilaurin, caprylic acid, arachidonic acid, glycerol 1-monocaprate, 1-dodecylazacycloheptan-2-one, acylcarnitines, acylcholines, C₁₋₁₀ alkyl esters thereof (e.g., methyl, isopropyl and t-butyl), and mono- and di-glycerides thereof (i.e., oleate, laurate, caprate, myristate, palmitate, stearate, linoleate, etc.) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, p.92; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7, 1-33; El Hariri et al., *J. Pharm. Pharmacol.*, 1992, 44, 651-654).

Bile salts: The physiological role of bile includes the facilitation of dispersion and absorption of lipids and fat-soluble vitamins (Brunton, Chapter 38 in: Goodman & Gilman's *The Pharmacological Basis of Therapeutics*, 9th Ed., Hardman et al. Eds., McGraw-Hill, New York, 1996, pp. 934-935). Various natural bile salts, and their synthetic derivatives, act as penetration enhancers. Thus the term "bile salts" includes any of the naturally occurring components of bile as well as any of their synthetic derivatives. The bile salts of the invention include, for example, cholic acid (or its pharmaceutically acceptable sodium salt, sodium cholate), dehydrocholic acid (sodium dehydrocholate), deoxycholic acid (sodium deoxycholate), gluchocholic acid (sodium gluchocholate), glycholic acid (sodium glycocholate), glycodeoxycholic acid (sodium glycodeoxycholate), taurocholic acid (sodium taurocholate), taurodeoxycholic acid (sodium taurodeoxycholate), chenodeoxycholic acid (sodium chenodeoxycholate),

-44-

- ursodeoxycholic acid (UDCA), sodium tauro-24,25-dihydrofusidate (STDHF), sodium glycodihydrofusidate and polyoxyethylene-9-lauryl ether (POE) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, page 92; 5 Swinyard, Chapter 39 In: *Remington's Pharmaceutical Sciences*, 18th Ed., Gennaro, ed., Mack Publishing Co., Easton, PA, 1990, pages 782-783; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7, 1-33; Yamamoto et al., *J. Pharm. Exp. Ther.*, 1992, 263, 25; 10 Yamashita et al., *J. Pharm. Sci.*, 1990, 79, 579-583).

Chelating Agents: Chelating agents, as used in connection with the present invention, can be defined as compounds that remove metallic ions from solution by forming complexes therewith, with the result that 15 absorption of oligonucleotides through the mucosa is enhanced. With regards to their use as penetration enhancers in the present invention, chelating agents have the added advantage of also serving as DNase inhibitors, as most characterized DNA nucleases require a divalent metal 20 ion for catalysis and are thus inhibited by chelating agents (Jarrett, *J. Chromatogr.*, 1993, 618, 315-339). Chelating agents of the invention include but are not limited to disodium ethylenediaminetetraacetate (EDTA), citric acid, salicylates (e.g., sodium salicylate, 5- 25 methoxysalicylate and homovanilate), N-acyl derivatives of collagen, laureth-9 and N-amino acyl derivatives of beta-diketones (enamines) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, page 92; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 30 7, 1-33; Buur et al., *J. Control Rel.*, 1990, 14, 43-51).

Non-chelating non-surfactants: As used herein, non-chelating non-surfactant penetration enhancing compounds can be defined as compounds that demonstrate insignificant activity as chelating agents or as surfactants but that

-45-

nonetheless enhance absorption of oligonucleotides through the alimentary mucosa (Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7, 1-33). This class of penetration enhancers include, for example,

5 unsaturated cyclic ureas, 1-alkyl- and 1-alkenylazacyclo- alkanone derivatives (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, page 92); and non- steroidial anti-inflammatory agents such as diclofenac sodium, indomethacin and phenylbutazone (Yamashita et al.,

10 *J. Pharm. Pharmacol.*, 1987, 39, 621-626).

Agents that enhance uptake of oligonucleotides at the cellular level may also be added to the pharmaceutical and other compositions of the present invention. For example, cationic lipids, such as lipofectin (Junichi et al, U.S. Patent No. 5,705,188), cationic glycerol derivatives, and polycationic molecules, such as polylysine (Lollo et al., PCT Application WO 97/30731), are also known to enhance the cellular uptake of oligonucleotides.

Other agents may be utilized to enhance the penetration of the administered nucleic acids, including glycols such as ethylene glycol and propylene glycol, pyrrols such as 2-pyrrol, azones, and terpenes such as limonene and menthone.

25 Carriers

Certain compositions of the present invention also incorporate carrier compounds in the formulation. As used herein, "carrier compound" or "carrier" can refer to a nucleic acid, or analog thereof, which is inert (i.e., does not possess biological activity *per se*) but is recognized as a nucleic acid by *in vivo* processes that reduce the bioavailability of a nucleic acid having biological activity by, for example, degrading the biologically active nucleic acid or promoting its removal from circulation.

-46-

The coadministration of a nucleic acid and a carrier compound, typically with an excess of the latter substance, can result in a substantial reduction of the amount of nucleic acid recovered in the liver, kidney or other
5 extracirculatory reservoirs, presumably due to competition between the carrier compound and the nucleic acid for a common receptor. For example, the recovery of a partially phosphorothioate oligonucleotide in hepatic tissue can be reduced when it is coadministered with polyinosinic acid,
10 dextran sulfate, polycytidic acid or 4-acetamido-4' isothiocyanostilbene-2,2'-disulfonic acid (Miyao et al., *Antisense Res. Dev.*, 1995, 5, 115-121; Takakura et al., *Antisense & Nucl. Acid Drug Dev.*, 1996, 6, 177-183).

Excipients

15 In contrast to a carrier compound, a "pharmaceutical carrier" or "excipient" is a pharmaceutically acceptable solvent, suspending agent or any other pharmacologically inert vehicle for delivering one or more nucleic acids to an animal. The excipient may be liquid or solid and is
20 selected, with the planned manner of administration in mind, so as to provide for the desired bulk, consistency, etc., when combined with a nucleic acid and the other components of a given pharmaceutical composition. Typical pharmaceutical carriers include, but are not limited to,
25 binding agents (e.g., pregelatinized maize starch, polyvinylpyrrolidone or hydroxypropyl methylcellulose, etc.); fillers (e.g., lactose and other sugars, microcrystalline cellulose, pectin, gelatin, calcium sulfate, ethyl cellulose, polyacrylates or calcium hydrogen phosphate, etc.); lubricants (e.g., magnesium stearate, talc, silica, colloidal silicon dioxide, stearic acid, metallic stearates, hydrogenated vegetable oils, corn starch, polyethylene glycols, sodium benzoate, sodium acetate, etc.); disintegrants (e.g., starch, sodium starch

-47-

glycolate, etc.); and wetting agents (e.g., sodium lauryl sulphate, etc.).

Pharmaceutically acceptable organic or inorganic excipient suitable for non-parenteral administration which do not deleteriously react with nucleic acids can also be used to formulate the compositions of the present invention. Suitable pharmaceutically acceptable carriers include, but are not limited to, water, salt solutions, alcohols, polyethylene glycols, gelatin, lactose, amylose, magnesium stearate, talc, silicic acid, viscous paraffin, hydroxymethylcellulose, polyvinylpyrrolidone and the like.

Formulations for topical administration of nucleic acids may include sterile and non-sterile aqueous solutions, non-aqueous solutions in common solvents such as alcohols, or solutions of the nucleic acids in liquid or solid oil bases. The solutions may also contain buffers, diluents and other suitable additives. Pharmaceutically acceptable organic or inorganic excipients suitable for non-parenteral administration which do not deleteriously react with nucleic acids can be used.

Suitable pharmaceutically acceptable excipients include, but are not limited to, water, salt solutions, alcohol, polyethylene glycols, gelatin, lactose, amylose, magnesium stearate, talc, silicic acid, viscous paraffin, hydroxymethylcellulose, polyvinylpyrrolidone and the like.

Other Components

The compositions of the present invention may additionally contain other adjunct components conventionally found in pharmaceutical compositions, at their art-established usage levels. Thus, for example, the compositions may contain additional, compatible, pharmaceutically-active materials such as, for example, antipruritics, astringents, local anesthetics or anti-inflammatory agents, or may contain additional

-48-

materials useful in physically formulating various dosage forms of the compositions of the present invention, such as dyes, flavoring agents, preservatives, antioxidants, opacifiers, thickening agents and stabilizers. However, 5 such materials, when added, should not unduly interfere with the biological activities of the components of the compositions of the present invention. The formulations can be sterilized and, if desired, mixed with auxiliary agents, e.g., lubricants, preservatives, stabilizers, 10 wetting agents, emulsifiers, salts for influencing osmotic pressure, buffers, colorings, flavorings and/or aromatic substances and the like which do not deleteriously interact with the nucleic acid(s) of the formulation.

Aqueous suspensions may contain substances which 15 increase the viscosity of the suspension including, for example, sodium carboxymethylcellulose, sorbitol and/or dextran. The suspension may also contain stabilizers.

Certain embodiments of the invention provide pharmaceutical compositions containing (a) one or more 20 antisense compounds and (b) one or more other chemotherapeutic agents which function by a non-antisense mechanism. Examples of such chemotherapeutic agents include, but are not limited to, anticancer drugs such as daunorubicin, dactinomycin, doxorubicin, bleomycin, 25 mitomycin, nitrogen mustard, chlorambucil, melphalan, cyclophosphamide, 6-mercaptopurine, 6-thioguanine, cytarabine (CA), 5-fluorouracil (5-FU), floxuridine (5-FUDR), methotrexate (MTX), colchicine, vincristine, vinblastine, etoposide, teniposide, cisplatin and 30 diethylstilbestrol (DES). See, generally, *The Merck Manual of Diagnosis and Therapy*, 15th Ed., Berkow et al., eds., 1987, Rahway, N.J., pages 1206-1228). Anti-inflammatory drugs, including but not limited to nonsteroidal anti-inflamatory drugs and corticosteroids, and antiviral 35 drugs, including but not limited to ribivirin, vidarabine,

-49-

acyclovir and ganciclovir, may also be combined in compositions of the invention. See, generally, *The Merck Manual of Diagnosis and Therapy*, 15th Ed., Berkow et al., eds., 1987, Rahway, N.J., pages 2499-2506 and 46-49,
5 respectively). Other non-antisense chemotherapeutic agents are also within the scope of this invention. Two or more combined compounds may be used together or sequentially.

In another related embodiment, compositions of the invention may contain one or more antisense compounds,
10 particularly oligonucleotides, targeted to a first nucleic acid and one or more additional antisense compounds targeted to a second nucleic acid target. Numerous examples of antisense compounds are known in the art. Two or more combined compounds may be used together or sequentially.

15 The formulation of therapeutic compositions and their subsequent administration is believed to be within the skill of those in the art. Dosing is dependent on severity and responsiveness of the disease state to be treated, with the course of treatment lasting from several days to
20 several months, or until a cure is effected or a diminution of the disease state is achieved. Optimal dosing schedules can be calculated from measurements of drug accumulation in the body of the patient. Persons of ordinary skill can easily determine optimum dosages, dosing methodologies and
25 repetition rates. Optimum dosages may vary depending on the relative potency of individual oligonucleotides, and can generally be estimated based on EC₅₀s found to be effective in in vitro and in vivo animal models. In general, dosage is from 0.01 ug to 100 g per kg of body
30 weight, and may be given once or more daily, weekly, monthly or yearly, or even once every 2 to 20 years. Persons of ordinary skill in the art can easily estimate repetition rates for dosing based on measured residence times and concentrations of the drug in bodily fluids or
35 tissues. Following successful treatment, it may be

-50-

desirable to have the patient undergo maintenance therapy to prevent the recurrence of the disease state, wherein the oligonucleotide is administered in maintenance doses, ranging from 0.01 ug to 100 g per kg of body weight, once 5 or more daily, to once every 20 years.

While the present invention has been described with specificity in accordance with certain of its preferred embodiments, the following examples serve only to illustrate the invention and are not intended to limit the 10 same.

EXAMPLES

Example 1

Nucleoside Phosphoramidites for Oligonucleotide Synthesis Deoxy and 2'-alkoxy amidites

15 2'-Deoxy and 2'-methoxy beta-cyanoethyldiisopropyl phosphoramidites were purchased from commercial sources (e.g. Chemgenes, Needham MA or Glen Research, Inc. Sterling VA). Other 2'-O-alkoxy substituted nucleoside amidites are prepared as described in U.S. Patent 5,506,351, herein 20 incorporated by reference. For oligonucleotides synthesized using 2'-alkoxy amidites, the standard cycle for unmodified oligonucleotides was utilized, except the wait step after pulse delivery of tetrazole and base was increased to 360 seconds.

25 Oligonucleotides containing 5-methyl-2'-deoxycytidine (5-Me-C) nucleotides were synthesized according to published methods [Sanghvi, et. al., *Nucleic Acids Research*, 1993, 21, 3197-3203] using commercially available phosphoramidites (Glen Research, Sterling VA or ChemGenes, 30 Needham MA).

2'-Fluoro amidites

2'-Fluorodeoxyadenosine amidites

2'-fluoro oligonucleotides were synthesized as described previously [Kawasaki, et. al., *J. Med. Chem.*,

-51-

1993, 36, 831-841] and United States patent 5,670,633, herein incorporated by reference. Briefly, the protected nucleoside N6-benzoyl-2'-deoxy-2'-fluoroadenosine was synthesized utilizing commercially available 9-beta-D-
5 arabinofuranosyladenine as starting material and by modifying literature procedures whereby the 2'-alpha-fluoro atom is introduced by a S_N2-displacement of a 2'-beta-trityl group. Thus N6-benzoyl-9-beta-D-arabinofuranosyladenine was selectively protected in moderate yield as the 3',5'-
10 ditetrahydropyranyl (THP) intermediate. Deprotection of the THP and N6-benzoyl groups was accomplished using standard methodologies and standard methods were used to obtain the 5'-dimethoxytrityl-(DMT) and 5'-DMT-3'-phosphoramidite intermediates.

15 **2'-Fluorodeoxyguanosine**

The synthesis of 2'-deoxy-2'-fluoroguanosine was accomplished using tetraisopropyldisiloxanyl (TPDS) protected 9-beta-D-arabinofuranosylguanine as starting material, and conversion to the intermediate diisobutyryl-
20 arabinofuranosylguanosine. Deprotection of the TPDS group was followed by protection of the hydroxyl group with THP to give diisobutyryl di-THP protected arabinofuranosylguanine. Selective O-deacylation and triflation was followed by treatment of the crude product
25 with fluoride, then deprotection of the THP groups. Standard methodologies were used to obtain the 5'-DMT- and 5'-DMT-3'-phosphoramidites.

2'-Fluorouridine

Synthesis of 2'-deoxy-2'-fluorouridine was
30 accomplished by the modification of a literature procedure in which 2,2'-anhydro-1-beta-D-arabinofuranosyluracil was treated with 70% hydrogen fluoride-pyridine. Standard procedures were used to obtain the 5'-DMT and 5'-DMT-
3'phosphoramidites.

-52-

2'-Fluorodeoxycytidine

2'-deoxy-2'-fluorocytidine was synthesized via amination of 2'-deoxy-2'-fluorouridine, followed by selective protection to give N4-benzoyl-2'-deoxy-2'-5 fluorocytidine. Standard procedures were used to obtain the 5'-DMT and 5'-DMT-3'phosphoramidites.

2'-O-(2-Methoxyethyl) modified amidites

2'-O-Methoxyethyl-substituted nucleoside amidites are prepared as follows, or alternatively, as per the methods 10 of Martin, P., *Helvetica Chimica Acta*, 1995, 78, 486-504.

2,2'-Anhydro[1-(beta-D-arabinofuranosyl)-5-methyluridine]

5-Methyluridine (ribosylthymine, commercially available through Yamasa, Choshi, Japan) (72.0 g, 0.279 M), 15 diphenylcarbonate (90.0 g, 0.420 M) and sodium bicarbonate (2.0 g, 0.024 M) were added to DMF (300 mL). The mixture was heated to reflux, with stirring, allowing the evolved carbon dioxide gas to be released in a controlled manner. After 1 hour, the slightly darkened solution was 20 concentrated under reduced pressure. The resulting syrup was poured into diethylether (2.5 L), with stirring. The product formed a gum. The ether was decanted and the residue was dissolved in a minimum amount of methanol (ca. 400 mL). The solution was poured into fresh ether (2.5 L) 25 to yield a stiff gum. The ether was decanted and the gum was dried in a vacuum oven (60°C at 1 mm Hg for 24 h) to give a solid that was crushed to a light tan powder (57 g, 85% crude yield). The NMR spectrum was consistent with the structure, contaminated with phenol as its sodium salt (ca. 30 5%). The material was used as is for further reactions (or it can be purified further by column chromatography using a gradient of methanol in ethyl acetate (10-25%) to give a white solid, mp 222-4°C).

-53-

2'-O-Methoxyethyl-5-methyluridine

2,2'-Anhydro-5-methyluridine (195 g, 0.81 M), tris(2-methoxyethyl)borate (231 g, 0.98 M) and 2-methoxyethanol (1.2 L) were added to a 2 L stainless steel pressure vessel 5 and placed in a pre-heated oil bath at 160°C. After heating for 48 hours at 155-160°C, the vessel was opened and the solution evaporated to dryness and triturated with MeOH (200 mL). The residue was suspended in hot acetone (1 L). The insoluble salts were filtered, washed with acetone (150 10 mL) and the filtrate evaporated. The residue (280 g) was dissolved in CH₃CN (600 mL) and evaporated. A silica gel column (3 kg) was packed in CH₂Cl₂/acetone/MeOH (20:5:3) containing 0.5% Et₃NH. The residue was dissolved in CH₂Cl₂, (250 mL) and adsorbed onto silica (150 g) prior to loading 15 onto the column. The product was eluted with the packing solvent to give 160 g (63%) of product. Additional material was obtained by reworking impure fractions.

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine

2'-O-Methoxyethyl-5-methyluridine (160 g, 0.506 M) was 20 co-evaporated with pyridine (250 mL) and the dried residue dissolved in pyridine (1.3 L). A first aliquot of dimethoxytrityl chloride (94.3 g, 0.278 M) was added and the mixture stirred at room temperature for one hour. A second aliquot of dimethoxytrityl chloride (94.3 g, 0.278 25 M) was added and the reaction stirred for an additional one hour. Methanol (170 mL) was then added to stop the reaction. HPLC showed the presence of approximately 70% product. The solvent was evaporated and triturated with CH₃CN (200 mL). The residue was dissolved in CHCl₃ (1.5 L) 30 and extracted with 2x500 mL of saturated NaHCO₃ and 2x500 mL of saturated NaCl. The organic phase was dried over Na₂SO₄, filtered and evaporated. 275 g of residue was obtained. The residue was purified on a 3.5 kg silica gel column, packed and eluted with EtOAc/hexane/acetone (5:5:1) 35 containing 0.5% Et₃NH. The pure fractions were evaporated

-54-

to give 164 g of product. Approximately 20 g additional was obtained from the impure fractions to give a total yield of 183 g (57%).

3'-O-Acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-
5 methyluridine

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine (106 g, 0.167 M), DMF/pyridine (750 mL of a 3:1 mixture prepared from 562 mL of DMF and 188 mL of pyridine) and acetic anhydride (24.38 mL, 0.258 M) were combined and 10 stirred at room temperature for 24 hours. The reaction was monitored by TLC by first quenching the TLC sample with the addition of MeOH. Upon completion of the reaction, as judged by TLC, MeOH (50 mL) was added and the mixture evaporated at 35°C. The residue was dissolved in CHCl₃ (800 15 mL) and extracted with 2x200 mL of saturated sodium bicarbonate and 2x200 mL of saturated NaCl. The water layers were back extracted with 200 mL of CHCl₃. The combined organics were dried with sodium sulfate and evaporated to give 122 g of residue (approx. 90% product). 20 The residue was purified on a 3.5 kg silica gel column and eluted using EtOAc/hexane(4:1). Pure product fractions were evaporated to yield 96 g (84%). An additional 1.5 g was recovered from later fractions.

3'-O-Acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-
25 methyl-4-triazoleuridine

A first solution was prepared by dissolving 3'-O-acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine (96 g, 0.144 M) in CH₃CN (700 mL) and set aside. Triethylamine (189 mL, 1.44 M) was added to a 30 solution of triazole (90 g, 1.3 M) in CH₃CN (1 L), cooled to -5°C and stirred for 0.5 h using an overhead stirrer. POCl₃ was added dropwise, over a 30 minute period, to the stirred solution maintained at 0-10°C, and the resulting mixture stirred for an additional 2 hours. The first solution was 35 added dropwise, over a 45 minute period, to the latter

-55-

solution. The resulting reaction mixture was stored overnight in a cold room. Salts were filtered from the reaction mixture and the solution was evaporated. The residue was dissolved in EtOAc (1 L) and the insoluble 5 solids were removed by filtration. The filtrate was washed with 1x300 mL of NaHCO₃, and 2x300 mL of saturated NaCl, dried over sodium sulfate and evaporated. The residue was triturated with EtOAc to give the title compound.

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-

10 methylcytidine

A solution of 3'-O-acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyl-4-triazoleuridine (103 g, 0.141 M) in dioxane (500 mL) and NH₄OH (30 mL) was stirred at room temperature for 2 hours. The dioxane solution was 15 evaporated and the residue azeotroped with MeOH (2x200 mL). The residue was dissolved in MeOH (300 mL) and transferred to a 2 liter stainless steel pressure vessel. MeOH (400 mL) saturated with NH₃ gas was added and the vessel heated to 100°C for 2 hours (TLC showed complete conversion). The 20 vessel contents were evaporated to dryness and the residue was dissolved in EtOAc (500 mL) and washed once with saturated NaCl (200 mL). The organics were dried over sodium sulfate and the solvent was evaporated to give 85 g (95%) of the title compound.

25 N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methyl-cytidine (85 g, 0.134 M) was dissolved in DMF (800 mL) and benzoic anhydride (37.2 g, 0.165 M) was added with 30 stirring. After stirring for 3 hours, TLC showed the reaction to be approximately 95% complete. The solvent was evaporated and the residue azeotroped with MeOH (200 mL). The residue was dissolved in CHCl₃ (700 mL) and extracted with saturated NaHCO₃ (2x300 mL) and saturated NaCl (2x300 35 mL), dried over MgSO₄ and evaporated to give a residue (96

-56-

g). The residue was chromatographed on a 1.5 kg silica column using EtOAc/hexane (1:1) containing 0.5% Et₃NH as the eluting solvent. The pure product fractions were evaporated to give 90 g (90%) of the title compound.

5 **N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine-3'-amidite**

N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine (74 g, 0.10 M) was dissolved in CH₂Cl₂ (1 L). Tetrazole diisopropylamine (7.1 g) and 2-cyanoethoxy-tetra-10 (isopropyl)phosphite (40.5 mL, 0.123 M) were added with stirring, under a nitrogen atmosphere. The resulting mixture was stirred for 20 hours at room temperature (TLC showed the reaction to be 95% complete). The reaction mixture was extracted with saturated NaHCO₃, (1x300 mL) and 15 saturated NaCl (3x300 mL). The aqueous washes were back-extracted with CH₂Cl₂ (300 mL), and the extracts were combined, dried over MgSO₄, and concentrated. The residue obtained was chromatographed on a 1.5 kg silica column using EtOAc/hexane (3:1) as the eluting solvent. The pure 20 fractions were combined to give 90.6 g (87%) of the title compound.

2'-O-(Aminooxyethyl) nucleoside amidites and 2'-O-(dimethylaminooxyethyl) nucleoside amidites

2'-(Dimethylaminooxyethoxy) nucleoside amidites

25 2'-(Dimethylaminooxyethoxy) nucleoside amidites [also known in the art as 2'-O-(dimethylaminooxyethyl) nucleoside amidites] are prepared as described in the following paragraphs. Adenosine, cytidine and guanosine nucleoside amidites are prepared similarly to the thymidine (5-methyluridine) except the exocyclic amines are protected with a benzoyl moiety in the case of adenosine and cytidine and with isobutyryl in the case of guanosine.

-57-

5'-O-tert-Butyldiphenylsilyl-O²-2'-anhydro-5-methyluridine

O²-2'-anhydro-5-methyluridine (Pro. Bio. Sint., Varese, Italy, 100.0g, 0.416 mmol), dimethylaminopyridine (0.66g, 5 0.013eq, 0.0054mmol) were dissolved in dry pyridine (500 ml) at ambient temperature under an argon atmosphere and with mechanical stirring. tert-Butyldiphenylchlorosilane (125.8g, 119.0mL, 1.1eq, 0.458mmol) was added in one portion. The reaction was stirred for 16 h at ambient 10 temperature. TLC (Rf 0.22, ethyl acetate) indicated a complete reaction. The solution was concentrated under reduced pressure to a thick oil. This was partitioned between dichloromethane (1 L) and saturated sodium bicarbonate (2x1 L) and brine (1 L). The organic layer was 15 dried over sodium sulfate and concentrated under reduced pressure to a thick oil. The oil was dissolved in a 1:1 mixture of ethyl acetate and ethyl ether (600mL) and the solution was cooled to -10°C. The resulting crystalline product was collected by 20 filtration, washed with ethyl ether (3x200 mL) and dried (40°C, 1mm Hg, 24 h) to 149g (74.8%) of white solid. TLC and NMR were consistent with pure product.

5'-O-tert-Butyldiphenylsilyl-2'-O-(2-hydroxyethyl)-5-methyluridine

25 In a 2 L stainless steel, unstirred pressure reactor was added borane in tetrahydrofuran (1.0 M, 2.0 eq, 622 mL). In the fume hood and with manual stirring, ethylene glycol (350 mL, excess) was added cautiously at first until the evolution of hydrogen gas subsided. 5'-O-tert- 30 Butyldiphenylsilyl-O²-2'-anhydro-5-methyluridine (149 g, 0.311 mol) and sodium bicarbonate (0.074 g, 0.003 eq) were added with manual stirring. The reactor was sealed and heated in an oil bath until an internal temperature of 160 °C was reached and then maintained for 16 h (pressure < 100

-58-

psig). The reaction vessel was cooled to ambient and opened. TLC (R_f 0.67 for desired product and R_f 0.82 for ara-T side product, ethyl acetate) indicated about 70% conversion to the product. In order to avoid additional 5 side product formation, the reaction was stopped, concentrated under reduced pressure (10 to 1mm Hg) in a warm water bath (40-100°C) with the more extreme conditions used to remove the ethylene glycol. [Alternatively, once the low boiling solvent is gone, the remaining solution can 10 be partitioned between ethyl acetate and water. The product will be in the organic phase.] The residue was purified by column chromatography (2kg silica gel, ethyl acetate-hexanes gradient 1:1 to 4:1). The appropriate fractions were combined, stripped and dried to product as a 15 white crisp foam (84g, 50%), contaminated starting material (17.4g) and pure reusable starting material 20g. The yield based on starting material less pure recovered starting material was 58%. TLC and NMR were consistent with 99% pure product.

20 2'-O-([2-phthalimidoxy]ethyl)-5'-t-butyldiphenylsilyl-
 5-methyluridine
 5'-O-tert-Butyldiphenylsilyl-2'-O-(2-hydroxyethyl)-5-
 methyluridine (20g, 36.98mmol) was mixed with
 triphenylphosphine (11.63g, 44.36mmol) and N-
25 hydroxypthalimide (7.24g, 44.36mmol). It was then dried
 over P_2O_5 under high vacuum for two days at 40°C. The
 reaction mixture was flushed with argon and dry THF
 (369.8mL, Aldrich, sure seal bottle) was added to get a
 clear solution. Diethyl-azodicarboxylate (6.98mL,
30 44.36mmol) was added dropwise to the reaction mixture. The
 rate of addition is maintained such that resulting deep red
 coloration is just discharged before adding the next drop.
 After the addition was complete, the reaction was stirred
 for 4 hrs. By that time TLC showed the completion of the
35 reaction (ethylacetate:hexane, 60:40). The solvent was

-59-

evaporated in vacuum. Residue obtained was placed on a flash column and eluted with ethyl acetate:hexane (60:40), to get 2'-O-([2-phthalimidoxy)ethyl]-5'-t-butylidiphenylsilyl-5-methyluridine as white foam (21.819 g, 5 86%).

5'-O-tert-butyldiphenylsilyl-2'-O-[(2-formadoximinoxy)ethyl]-5-methyluridine

2'-O-([2-phthalimidoxy)ethyl]-5'-t-butyldiphenylsilyl-5-methyluridine (3.1g, 4.5mmol) was dissolved in dry CH₂Cl₂, 10 (4.5mL) and methylhydrazine (300mL, 4.64mmol) was added dropwise at -10°C to 0°C. After 1 h the mixture was filtered, the filtrate was washed with ice cold CH₂Cl₂, and the combined organic phase was washed with water, brine and dried over anhydrous Na₂SO₄. The solution was concentrated 15 to get 2'-O-(aminoxyethyl) thymidine, which was then dissolved in MeOH (67.5mL). To this formaldehyde (20% aqueous solution, w/w, 1.1 eq.) was added and the resulting mixture was stirred for 1 h. Solvent was removed under vacuum; residue chromatographed to get 5'-O-tert- 20 butyldiphenylsilyl-2'-O-[(2-formadoximinoxy) ethyl]-5-methyluridine as white foam (1.95 g, 78%).

5'-O-tert-Butyldiphenylsilyl-2'-O-[N,N-dimethylaminoxyethyl]-5-methyluridine

5'-O-tert-butyldiphenylsilyl-2'-O-[(2-formadoximinoxy)ethyl]-5-methyluridine (1.77g, 3.12mmol) 25 was dissolved in a solution of 1M pyridinium p-toluenesulfonate (PPTS) in dry MeOH (30.6mL). Sodium cyanoborohydride (0.39g, 6.13mmol) was added to this solution at 10°C under inert atmosphere. The reaction 30 mixture was stirred for 10 minutes at 10°C. After that the reaction vessel was removed from the ice bath and stirred at room temperature for 2 h, the reaction monitored by TLC (5% MeOH in CH₂Cl₂). Aqueous NaHCO₃ solution (5%, 10mL) was added and extracted with ethyl acetate (2x20mL). Ethyl

-60-

acetate phase was dried over anhydrous Na_2SO_4 , evaporated to dryness. Residue was dissolved in a solution of 1M PPTS in MeOH (30.6mL). Formaldehyde (20% w/w, 30mL, 3.37mmol) was added and the reaction mixture was stirred at room temperature for 10 minutes. Reaction mixture cooled to 10°C in an ice bath, sodium cyanoborohydride (0.39g, 6.13mmol) was added and reaction mixture stirred at 10°C for 10 minutes. After 10 minutes, the reaction mixture was removed from the ice bath and stirred at room temperature for 2 hrs. To the reaction mixture 5% NaHCO_3 (25mL) solution was added and extracted with ethyl acetate (2x25mL). Ethyl acetate layer was dried over anhydrous Na_2SO_4 and evaporated to dryness. The residue obtained was purified by flash column chromatography and eluted with 5% MeOH in CH_2Cl_2 , to get 5'-O-tert-butyldiphenylsilyl-2'-O-[N,N-dimethylaminoxyethyl]-5-methyluridine as a white foam (14.6g, 80%).

2'-O-(dimethylaminoxyethyl)-5-methyluridine

Triethylamine trihydrofluoride (3.91mL, 24.0mmol) was dissolved in dry THF and triethylamine (1.67mL, 12mmol, dry, kept over KOH). This mixture of triethylamine-2HF was then added to 5'-O-tert-butyldiphenylsilyl-2'-O-[N,N-dimethylaminoxyethyl]-5-methyluridine (1.40g, 2.4mmol) and stirred at room temperature for 24 hrs. Reaction was monitored by TLC (5% MeOH in CH_2Cl_2). Solvent was removed under vacuum and the residue placed on a flash column and eluted with 10% MeOH in CH_2Cl_2 , to get 2'-O-(dimethylaminoxyethyl)-5-methyluridine (766mg, 92.5%).

5'-O-DMT-2'-O-(dimethylaminoxyethyl)-5-methyluridine

2'-O-(dimethylaminoxyethyl)-5-methyluridine (750mg, 2.17mmol) was dried over P_2O_5 under high vacuum overnight at 40°C. It was then co-evaporated with anhydrous pyridine (20mL). The residue obtained was dissolved in pyridine (11mL) under argon atmosphere. 4-dimethylaminopyridine (26.5mg, 2.60mmol), 4,4'-dimethoxytrityl chloride (880mg,

-61-

2.60mmol) was added to the mixture and the reaction mixture was stirred at room temperature until all of the starting material disappeared. Pyridine was removed under vacuum and the residue chromatographed and eluted with 10% MeOH in 5 CH₂Cl₂ (containing a few drops of pyridine) to get 5'-O-DMT-2'-O-(dimethylamino-oxyethyl)-5-methyluridine (1.13g, 80%).

5'-O-DMT-2'-O-(2-N,N-dimethylaminoxyethyl)-5-methyluridine-3'-(2-cyanoethyl)-N,N-diisopropylphosphoramidite]

10 5'-O-DMT-2'-O-(dimethylaminoxyethyl)-5-methyluridine (1.08g, 1.67mmol) was co-evaporated with toluene (20mL). To the residue N,N-diisopropylamine tetrazonide (0.29g, 1.67mmol) was added and dried over P₂O₅ under high vacuum overnight at 40°C. Then the reaction mixture was dissolved 15 in anhydrous acetonitrile (8.4mL) and 2-cyanoethyl-N,N,N¹,N¹-tetraisopropylphosphoramidite (2.12mL, 6.08mmol) was added. The reaction mixture was stirred at ambient temperature for 4 hrs under inert atmosphere. The progress of the reaction was monitored by TLC (hexane:ethyl acetate 20 1:1). The solvent was evaporated, then the residue was dissolved in ethyl acetate (70mL) and washed with 5% aqueous NaHCO₃ (40mL). Ethyl acetate layer was dried over anhydrous Na₂SO₄ and concentrated. Residue obtained was chromatographed (ethyl acetate as eluent) to get 5'-O-DMT-25 2'-O-(2-N,N-dimethylaminoxyethyl)-5-methyluridine-3'-(2-cyanoethyl)-N,N-diisopropylphosphoramidite] as a foam (1.04g, 74.9%).

2'-(Aminooxyethoxy) nucleoside amidites

2'-(Aminooxyethoxy) nucleoside amidites [also known in 30 the art as 2'-O-(aminooxyethyl) nucleoside amidites] are prepared as described in the following paragraphs. Adenosine, cytidine and thymidine nucleoside amidites are prepared similarly.

-62-

N2-isobutyryl-6-O-diphenylcarbamoyl-2'-O-(2-ethylacetyl)-5'-O-(4,4'-dimethoxytrityl)guanosine-3'-[(2-cyanoethyl)-N,N-diisopropylphosphoramidite]

The 2'-O-aminoxyethyl guanosine analog may be

- 5 obtained by selective 2'-O-alkylation of diaminopurine riboside. Multigram quantities of diaminopurine riboside may be purchased from Schering AG (Berlin) to provide 2'-O-(2-ethylacetyl) diaminopurine riboside along with a minor amount of the 3'-O-isomer. 2'-O-(2-ethylacetyl)
- 10 diaminopurine riboside may be resolved and converted to 2'-O-(2-ethylacetyl)guanosine by treatment with adenosine deaminase. (McGee, D. P. C., Cook, P. D., Guinossso, C. J., WO 94/02501 A1 940203.) Standard protection procedures should afford 2'-O-(2-ethylacetyl)-5'-O-(4,4'-
- 15 dimethoxytrityl)guanosine and 2-N-isobutyryl-6-O-diphenylcarbamoyl-2'-O-(2-ethylacetyl)-5'-O-(4,4'-dimethoxytrityl)guanosine which may be reduced to provide 2-N-isobutyryl-6-O-diphenylcarbamoyl-2'-O-(2-ethylacetyl)-5'-O-(4,4'-dimethoxytrityl)guanosine. As before the
- 20 hydroxyl group may be displaced by N-hydroxyphthalimide via a Mitsunobu reaction, and the protected nucleoside may phosphitylated as usual to yield 2-N-isobutyryl-6-O-diphenylcarbamoyl-2'-O-(2-ethylacetyl)-5'-O-(4,4'-dimethoxytrityl)guanosine-3'-[(2-cyanoethyl)-N,N-
- 25 diisopropylphosphoramidite].

2'-dimethylaminoethoxyethoxy (2'-DMAEOE) nucleoside amidites

- 2'-dimethylaminoethoxyethoxy nucleoside amidites (also known in the art as 2'-O-dimethylaminoethoxyethyl, i.e.,
- 30 2'-O-CH₂-O-CH₂-N(CH₃)₂, or 2'-DMAEOE nucleoside amidites) are prepared as follows. Other nucleoside amidites are prepared similarly.

2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyl uridine
2[2-(Dimethylamino)ethoxy]ethanol (Aldrich, 6.66 g, 50

-63-

mmol) is slowly added to a solution of borane in tetrahydrofuran (1 M, 10 mL, 10 mmol) with stirring in a 100 mL bomb. Hydrogen gas evolves as the solid dissolves. O²⁻, 2'-anhydro-5-methyluridine (1.2 g, 5 mmol), and sodium bicarbonate (2.5 mg) are added and the bomb is sealed, placed in an oil bath and heated to 155°C for 26 hours. The bomb is cooled to room temperature and opened. The crude solution is concentrated and the residue partitioned between water (200 mL) and hexanes (200 mL). The excess phenol is extracted into the hexane layer. The aqueous layer is extracted with ethyl acetate (3x200 mL) and the combined organic layers are washed once with water, dried over anhydrous sodium sulfate and concentrated. The residue is columned on silica gel using methanol/methylene chloride 1:20 (which has 2% triethylamine) as the eluent. As the column fractions are concentrated a colorless solid forms which is collected to give the title compound as a white solid.

5'-O-dimethoxytrityl-2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyl uridine
To 0.5 g (1.3 mmol) of 2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyl uridine in anhydrous pyridine (8 mL), triethylamine (0.36 mL) and dimethoxytrityl chloride (DMT-Cl, 0.87 g, 2 eq.) are added and stirred for 1 hour. The reaction mixture is poured into water (200 mL) and extracted with CH₂Cl₂ (2x200 mL). The combined CH₂Cl₂ layers are washed with saturated NaHCO₃ solution, followed by saturated NaCl solution and dried over anhydrous sodium sulfate. Evaporation of the solvent followed by silica gel chromatography using MeOH:CH₂Cl₂:Et₃N (20:1, v/v, with 1% triethylamine) gives the title compound.

-64-

5'-O-Dimethoxytrityl-2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyl uridine-3'-O-(cyanoethyl-N,N-diisopropyl)phosphoramidite
Diisopropylaminotetrazolide (0.6 g) and 2-cyanoethoxy-

5 N,N-diisopropyl phosphoramidite (1.1 mL, 2 eq.) are added to a solution of 5'-O-dimethoxytrityl-2'-O-[2(2-N,N-dimethylaminoethoxy)ethyl]-5-methyluridine (2.17 g, 3 mmol) dissolved in CH₂Cl₂ (20 mL) under an atmosphere of argon. The reaction mixture is stirred overnight and the 10 solvent evaporated. The resulting residue is purified by silica gel flash column chromatography with ethyl acetate as the eluent to give the title compound.

Example 2

Oligonucleotide synthesis

15 Unsubstituted and substituted phosphodiester (P=O) oligonucleotides are synthesized on an automated DNA synthesizer (Applied Biosystems model 380B) using standard phosphoramidite chemistry with oxidation by iodine.

20 Phosphorothioates (P=S) are synthesized as for the phosphodiester oligonucleotides except the standard oxidation bottle was replaced by 0.2 M solution of 3H-1,2-benzodithiole-3-one 1,1-dioxide in acetonitrile for the stepwise thiation of the phosphite linkages. The thiation wait step was increased to 68 sec and was followed by the 25 capping step. After cleavage from the CPG column and deblocking in concentrated ammonium hydroxide at 55°C (18 h), the oligonucleotides were purified by precipitating twice with 2.5 volumes of ethanol from a 0.5 M NaCl solution. Phosphinate oligonucleotides are prepared as 30 described in U.S. Patent 5,508,270, herein incorporated by reference.

Alkyl phosphonate oligonucleotides are prepared as described in U.S. Patent 4,469,863, herein incorporated by reference.

-65-

3'-Deoxy-3'-methylene phosphonate oligonucleotides are prepared as described in U.S. Patents 5,610,289 or 5,625,050, herein incorporated by reference.

Phosphoramidite oligonucleotides are prepared as 5 described in U.S. Patent, 5,256,775 or U.S. Patent 5,366,878, herein incorporated by reference.

Alkylphosphonothioate oligonucleotides are prepared as described in published PCT applications PCT/US94/00902 and PCT/US93/06976 (published as WO 94/17093 and WO 94/02499, 10 respectively), herein incorporated by reference.

3'-Deoxy-3'-amino phosphoramidate oligonucleotides are prepared as described in U.S. Patent 5,476,925, herein incorporated by reference.

Phosphotriester oligonucleotides are prepared as 15 described in U.S. Patent 5,023,243, herein incorporated by reference.

Borano phosphate oligonucleotides are prepared as described in U.S. Patents 5,130,302 and 5,177,198, both herein incorporated by reference.

20 **Example 3**

Oligonucleoside Synthesis

Methylenemethylimino linked oligonucleosides, also identified as MMI linked oligonucleosides, methylenedimethylhydrazo linked oligonucleosides, also identified as 25 MDH linked oligonucleosides, and methylenecarbonylamino linked oligonucleosides, also identified as amide-3 linked oligonucleosides, and methyleneaminocarbonyl linked oligonucleosides, also identified as amide-4 linked oligonucleosides, as well as mixed backbone compounds having, for 30 instance, alternating MMI and P=O or P=S linkages are prepared as described in U.S. Patents 5,378,825, 5,386,023, 5,489,677, 5,602,240 and 5,610,289, all of which are herein incorporated by reference.

Formacetal and thioformacetal linked oligonucleosides 35 are prepared as described in U.S. Patents 5,264,562 and

-66-

5,264,564, herein incorporated by reference.

Ethylene oxide linked oligonucleosides are prepared as described in U.S. Patent 5,223,618, herein incorporated by reference.

5 **Example 4**

PNA Synthesis

Peptide nucleic acids (PNAs) are prepared in accordance with any of the various procedures referred to in Peptide Nucleic Acids (PNA): Synthesis, Properties and 10 Potential Applications, *Bioorganic & Medicinal Chemistry*, 1996, 4, 5-23. They may also be prepared in accordance with U.S. Patents 5,539,082, 5,700,922, and 5,719,262, herein incorporated by reference.

Example 5

15 **Synthesis of Chimeric Oligonucleotides**

Chimeric oligonucleotides, oligonucleosides or mixed oligonucleotides/oligonucleosides of the invention can be of several different types. These include a first type wherein the "gap" segment of linked nucleosides is 20 positioned between 5' and 3' "wing" segments of linked nucleosides and a second "open end" type wherein the "gap" segment is located at either the 3' or the 5' terminus of the oligomeric compound. Oligonucleotides of the first type are also known in the art as "gapmers" or gapped 25 oligonucleotides. Oligonucleotides of the second type are also known in the art as "hemimers" or "wingmers".

[2'-O-Me] -- [2'-deoxy] -- [2'-O-Me] Chimeric

Phosphorothioate Oligonucleotides

Chimeric oligonucleotides having 2'-O-alkyl 30 phosphorothioate and 2'-deoxy phosphorothioate oligonucleotide segments are synthesized using an Applied Biosystems automated DNA synthesizer Model 380B, as above. Oligonucleotides are synthesized using the automated synthesizer and 2'-deoxy-5'-dimethoxytrityl-3'-O-phosphor-

-67-

amidite for the DNA portion and 5'-dimethoxytrityl-2'-O-methyl-3'-O-phosphoramidite for 5' and 3' wings. The standard synthesis cycle is modified by increasing the wait step after the delivery of tetrazole and base to 600 s 5 repeated four times for RNA and twice for 2'-O-methyl. The fully protected oligonucleotide is cleaved from the support and the phosphate group is deprotected in 3:1 ammonia/ethanol at room temperature overnight then lyophilized to dryness. Treatment in methanolic ammonia 10 for 24 hrs at room temperature is then done to deprotect all bases and sample was again lyophilized to dryness. The pellet is resuspended in 1M TBAF in THF for 24 hrs at room temperature to deprotect the 2' positions. The reaction is then quenched with 1M TEAA and the sample is then reduced 15 to 1/2 volume by rotovac before being desalted on a G25 size exclusion column. The oligo recovered is then analyzed spectrophotometrically for yield and for purity by capillary electrophoresis and by mass spectrometry.

[2'-O-(2-Methoxyethyl)]--[2'-deoxy]--[2'-O-
20 (Methoxyethyl)] Chimeric Phosphorothioate
Oligonucleotides
[2'-O-(2-methoxyethyl)]--[2'-deoxy]--[-2'-O-(methoxyethyl)] chimeric phosphorothioate oligonucleotides were prepared as per the procedure above for the 2'-O-methyl 25 chimeric oligonucleotide, with the substitution of 2'-O-(methoxyethyl) amidites for the 2'-O-methyl amidites.

[2'-O-(2-Methoxyethyl) Phosphodiester]--[2'-deoxy Phosphorothioate]--[2'-O-(2-Methoxyethyl) Phosphodiester] Chimeric Oligonucleotides
30 [2'-O-(2-methoxyethyl) phosphodiester]--[2'-deoxy phosphorothioate]--[2'-O-(methoxyethyl) phosphodiester] chimeric oligonucleotides are prepared as per the above procedure for the 2'-O-methyl chimeric oligonucleotide with the substitution of 2'-O-(methoxyethyl) amidites for the

-68-

2'-O-methyl amidites, oxidization with iodine to generate the phosphodiester internucleotide linkages within the wing portions of the chimeric structures and sulfurization utilizing 3, H-1,2 benzodithiole-3-one 1,1 dioxide (Beaucage 5 Reagent) to generate the phosphorothioate internucleotide linkages for the center gap.

Other chimeric oligonucleotides, chimeric oligonucleosides and mixed chimeric oligonucleotides/oligonucleosides are synthesized according to United States patent 10 5,623,065, herein incorporated by reference.

Example 6

Oligonucleotide Isolation

After cleavage from the controlled pore glass column (Applied Biosystems) and deblocking in concentrated 15 ammonium hydroxide at 55°C for 18 hours, the oligonucleotides or oligonucleosides are purified by precipitation twice out of 0.5 M NaCl with 2.5 volumes ethanol. Synthesized oligonucleotides were analyzed by polyacrylamide gel electrophoresis on denaturing gels and 20 judged to be at least 85% full length material. The relative amounts of phosphorothioate and phosphodiester linkages obtained in synthesis were periodically checked by ³¹P nuclear magnetic resonance spectroscopy, and for some studies oligonucleotides were purified by HPLC, as 25 described by Chiang et al., J. Biol. Chem. 1991, 266, 18162-18171. Results obtained with HPLC-purified material were similar to those obtained with non-HPLC purified material.

Example 7

30 **Oligonucleotide Synthesis - 96 Well Plate Format**

Oligonucleotides were synthesized via solid phase P(III) phosphoramidite chemistry on an automated synthesizer capable of assembling 96 sequences simultaneously in a standard 96 well format.

-69-

Phosphodiester internucleotide linkages were afforded by oxidation with aqueous iodine. Phosphorothioate internucleotide linkages were generated by sulfurization utilizing 3,H-1,2 benzodithiole-3-one 1,1 dioxide (Beaucage Reagent) in anhydrous acetonitrile. Standard base-protected beta-cyanoethyldiisopropyl phosphoramidites were purchased from commercial vendors (e.g. PE-Applied Biosystems, Foster City, CA, or Pharmacia, Piscataway, NJ). Non-standard nucleosides are synthesized as per known literature or patented methods. They are utilized as base protected beta-cyanoethyldiisopropyl phosphoramidites.

Oligonucleotides were cleaved from support and deprotected with concentrated NH₄OH at elevated temperature (55-60°C) for 12-16 hours and the released product then dried in vacuo. The dried product was then re-suspended in sterile water to afford a master plate from which all analytical and test plate samples are then diluted utilizing robotic pipettors.

Example 8

20 Oligonucleotide Analysis - 96 Well Plate Format

The concentration of oligonucleotide in each well was assessed by dilution of samples and UV absorption spectroscopy. The full-length integrity of the individual products was evaluated by capillary electrophoresis (CE) in either the 96 well format (Beckman P/ACE™ MDQ) or, for individually prepared samples, on a commercial CE apparatus (e.g., Beckman P/ACE™ 5000, ABI 270). Base and backbone composition was confirmed by mass analysis of the compounds utilizing electrospray-mass spectroscopy. All assay test plates were diluted from the master plate using single and multi-channel robotic pipettors. Plates were judged to be acceptable if at least 85% of the compounds on the plate were at least 85% full length.

-70-

Example 9

Cell culture and oligonucleotide treatment

The effect of antisense compounds on target nucleic acid expression can be tested in any of a variety of cell types provided that the target nucleic acid is present at measurable levels. This can be routinely determined using, for example, PCR or Northern blot analysis. The following four cell types are provided for illustrative purposes, but other cell types can be routinely used, provided that the target is expressed in the cell type chosen. This can be readily determined by methods routine in the art, for example Northern blot analysis, Ribonuclease protection assays, or RT-PCR.

15 **T-24 cells:**

The transitional cell bladder carcinoma cell line T-24 was obtained from the American Type Culture Collection (ATCC) (Manassas, VA). T-24 cells were routinely cultured in complete McCoy's 5A basal media (Gibco/Life Technologies, Gaithersburg, MD) supplemented with 10% fetal calf serum (Gibco/Life Technologies, Gaithersburg, MD), penicillin 100 units per mL, and streptomycin 100 micrograms per mL (Gibco/Life Technologies, Gaithersburg, MD). Cells were routinely passaged by trypsinization and dilution when they reached 90% confluence. Cells were seeded into 96-well plates (Falcon-Primaria #3872) at a density of 7000 cells/well for use in RT-PCR analysis.

For Northern blotting or other analysis, cells may be seeded onto 100 mm or other standard tissue culture plates and treated similarly, using appropriate volumes of medium and oligonucleotide.

A549 cells:

The human lung carcinoma cell line A549 was obtained from the American Type Culture Collection (ATCC) (Manassas,

- 71 -

VA). A549 cells were routinely cultured in DMEM basal media (Gibco/Life Technologies, Gaithersburg, MD) supplemented with 10% fetal calf serum (Gibco/Life Technologies, Gaithersburg, MD), penicillin 100 units per 5 mL, and streptomycin 100 micrograms per mL (Gibco/Life Technologies, Gaithersburg, MD). Cells were routinely passaged by trypsinization and dilution when they reached 90% confluence.

10 NHDF cells:

Human neonatal dermal fibroblast (NHDF) were obtained from the Clonetics Corporation (Walkersville MD). NHDFs were routinely maintained in Fibroblast Growth Medium (Clonetics Corporation, Walkersville MD) supplemented as 15 recommended by the supplier. Cells were maintained for up to 10 passages as recommended by the supplier.

HEK cells:

Human embryonic keratinocytes (HEK) were obtained from 20 the Clonetics Corporation (Walkersville MD). HEKs were routinely maintained in Keratinocyte Growth Medium (Clonetics Corporation, Walkersville MD) formulated as recommended by the supplier. Cells were routinely maintained for up to 10 passages as recommended by the 25 supplier.

Treatment with antisense compounds:

When cells reached 80% confluency, they were treated with oligonucleotide. For cells grown in 96-well plates, 30 wells were washed once with 200 µL OPTI-MEM™-1 reduced-serum medium (Gibco BRL) and then treated with 130 µL of OPTI-MEM™-1 containing 3.75 µg/mL LIPOFECTIN™ (Gibco BRL) and the desired concentration of oligonucleotide. After 4- 7 hours of treatment, the medium was replaced with fresh

-72-

medium. Cells were harvested 16-24 hours after oligonucleotide treatment.

The concentration of oligonucleotide used varies from cell line to cell line. To determine the optimal 5 oligonucleotide concentration for a particular cell line, the cells are treated with a positive control oligonucleotide at a range of concentrations. For human cells the positive control oligonucleotide is ISIS 13920, **TCCGTCATCGCTCCTCAGGG**, SEQ ID NO: 1, a 2'-O-methoxyethyl 10 gapmer (2'-O-methoxyethyls shown in bold) with a phosphorothioate backbone which is targeted to human c-Ha-ras. For mouse or rat cells the positive control oligonucleotide is ISIS 15770, **ATGCATTCTGCCCAAGGA**, SEQ ID NO: 2, a 2'-O-methoxyethyl gapmer (2'-O-methoxyethyls shown 15 in bold) with a phosphorothioate backbone which is targeted to both mouse and rat c-raf. The concentration of positive control oligonucleotide that results in 80% inhibition of c-Ha-ras (for ISIS 13920) or c-raf (for ISIS 15770) mRNA is then utilized in subsequent experiments for that cell line. 20 If 80% inhibition is not achieved, the lowest concentration of positive control oligonucleotide that results in 60% inhibition of c-Ha-ras or c-raf mRNA is then utilized in subsequent experiments for that cell line. If 60% inhibition is not achieved, that particular cell line is 25 deemed as unsuitable for oligonucleotide transfection experiments.

Example 10

Analysis of oligonucleotide inhibition of Protein kinase C-theta expression

30 Antisense modulation of Protein kinase C-theta expression can be assayed in a variety of ways known in the art. For example, Protein kinase C-theta mRNA levels can be quantitated by, e.g., Northern blot analysis, competitive polymerase chain reaction (PCR), or real-time

-73-

PCR (RT-PCR). Real-time quantitative PCR is presently preferred. RNA analysis can be performed on total cellular RNA or poly(A)+ mRNA. Methods of RNA isolation are taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.1.1-4.2.9 and 4.5.1-4.5.3, John Wiley & Sons, Inc., 1993. Northern blot analysis is routine in the art and is taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.2.1-4.2.9, John Wiley & Sons, Inc., 1996. Real-time quantitative (PCR) can be conveniently accomplished using the commercially available ABI PRISM™ 7700 Sequence Detection System, available from PE-Applied Biosystems, Foster City, CA and used according to manufacturer's instructions. Prior to quantitative PCR analysis, primer-probe sets specific to the target gene being measured are evaluated for their ability to be "multiplexed" with a GAPDH amplification reaction. In multiplexing, both the target gene and the internal standard gene GAPDH are amplified concurrently in a single sample. In this analysis, mRNA isolated from untreated cells is serially diluted. Each dilution is amplified in the presence of primer-probe sets specific for GAPDH only, target gene only ("single-plexing"), or both (multiplexing). Following PCR amplification, standard curves of GAPDH and target mRNA signal as a function of dilution are generated from both the single-plexed and multiplexed samples. If both the slope and correlation coefficient of the GAPDH and target signals generated from the multiplexed samples fall within 10% of their corresponding values generated from the single-plexed samples, the primer-probe set specific for that target is deemed as multiplexable. Other methods of PCR are also known in the art.

Protein kinase C-theta protein levels can be quantitated in a variety of ways well known in the art,

- 74 -

such as immunoprecipitation, Western blot analysis (immunoblotting), ELISA or fluorescence-activated cell sorting (FACS). Antibodies directed to Protein kinase C-theta can be identified and obtained from a variety of
5 sources, such as the MSRS catalog of antibodies (Aerie Corporation, Birmingham, MI), or can be prepared via conventional antibody generation methods. Methods for preparation of polyclonal antisera are taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 11.12.1-11.12.9, John Wiley & Sons, Inc., 1997. Preparation of monoclonal antibodies is taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 11.4.1-11.11.5, John Wiley & Sons, Inc., 1997.
10 15 Immunoprecipitation methods are standard in the art and can be found at, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 10.16.1-10.16.11, John Wiley & Sons, Inc., 1998. Western blot (immunoblot) analysis is standard in the art and can
20 be found at, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 10.8.1-10.8.21, John Wiley & Sons, Inc., 1997. Enzyme-linked immunosorbent assays (ELISA) are standard in the art and can be found at, for example, Ausubel, F.M. et al., *Current
25 Protocols in Molecular Biology*, Volume 2, pp. 11.2.1-11.2.22, John Wiley & Sons, Inc., 1991.

Example 11

Poly(A)+ mRNA isolation

Poly(A)+ mRNA was isolated according to Miura et al.,
30 *Clin. Chem.*, 1996, 42, 1758-1764. Other methods for poly(A)+ mRNA isolation are taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.5.1-4.5.3, John Wiley & Sons, Inc., 1993. Briefly, for cells grown on 96-well plates,

-75-

growth medium was removed from the cells and each well was washed with 200 μ L cold PBS. 60 μ L lysis buffer (10 mM Tris-HCl, pH 7.6, 1 mM EDTA, 0.5 M NaCl, 0.5% NP-40, 20 mM vanadyl-ribonucleoside complex) was added to each well, the 5 plate was gently agitated and then incubated at room temperature for five minutes. 55 μ L of lysate was transferred to Oligo d(T) coated 96-well plates (AGCT Inc., Irvine CA). Plates were incubated for 60 minutes at room temperature, washed 3 times with 200 μ L of wash buffer (10 10 mM Tris-HCl pH 7.6, 1 mM EDTA, 0.3 M NaCl). After the final wash, the plate was blotted on paper towels to remove excess wash buffer and then air-dried for 5 minutes. 60 μ L of elution buffer (5 mM Tris-HCl pH 7.6), preheated to 70°C was added to each well, the plate was incubated on a 90°C 15 hot plate for 5 minutes, and the eluate was then transferred to a fresh 96-well plate.

Cells grown on 100 mm or other standard plates may be treated similarly, using appropriate volumes of all solutions.

20 **Example 12**

Total RNA Isolation

Total mRNA was isolated using an RNEASY 96™ kit and buffers purchased from Qiagen Inc. (Valencia CA) following the manufacturer's recommended procedures. Briefly, for 25 cells grown on 96-well plates, growth medium was removed from the cells and each well was washed with 200 μ L cold PBS. 100 μ L Buffer RLT was added to each well and the plate vigorously agitated for 20 seconds. 100 μ L of 70% ethanol was then added to each well and the contents mixed by 30 pipetting three times up and down. The samples were then transferred to the RNEASY 96™ well plate attached to a QIAVAC™ manifold fitted with a waste collection tray and attached to a vacuum source. Vacuum was applied for 15 seconds. 1 mL of Buffer RW1 was added to each well of the 35 RNEASY 96™ plate and the vacuum again applied for 15

- 76 -

seconds. 1 mL of Buffer RPE was then added to each well of the RNEASY 96™ plate and the vacuum applied for a period of 15 seconds. The Buffer RPE wash was then repeated and the vacuum was applied for an additional 10 minutes. The plate 5 was then removed from the QIAVAC™ manifold and blotted dry on paper towels. The plate was then re-attached to the QIAVAC™ manifold fitted with a collection tube rack containing 1.2 mL collection tubes. RNA was then eluted by pipetting 60 µL water into each well, incubating 1 minute, 10 and then applying the vacuum for 30 seconds. The elution step was repeated with an additional 60 µL water.

The repetitive pipetting and elution steps may be automated using a QIAGEN Bio-Robot 9604 (Qiagen, Inc., Valencia CA). Essentially, after lysing of the cells on 15 the culture plate, the plate is transferred to the robot deck where the pipetting, DNase treatment and elution steps are carried out.

Example 13

**Real-time Quantitative PCR Analysis of Protein kinase C-
20 theta mRNA Levels**

Quantitation of Protein kinase C-theta mRNA levels was determined by real-time quantitative PCR using the ABI PRISM™ 7700 Sequence Detection System (PE-Applied Biosystems, Foster City, CA) according to manufacturer's 25 instructions. This is a closed-tube, non-gel-based, fluorescence detection system which allows high-throughput quantitation of polymerase chain reaction (PCR) products in real-time. As opposed to standard PCR, in which amplification products are quantitated after the PCR is 30 completed, products in real-time quantitative PCR are quantitated as they accumulate. This is accomplished by including in the PCR reaction an oligonucleotide probe that anneals specifically between the forward and reverse PCR primers, and contains two fluorescent dyes. A reporter dye 35 (e.g., JOE, FAM, or VIC, obtained from either Operon

-77-

Technologies Inc., Alameda, CA or PE-Applied Biosystems, Foster City, CA) is attached to the 5' end of the probe and a quencher dye (e.g., TAMRA, obtained from either Operon Technologies Inc., Alameda, CA or PE-Applied Biosystems, 5 Foster City, CA) is attached to the 3' end of the probe. When the probe and dyes are intact, reporter dye emission is quenched by the proximity of the 3' quencher dye. During amplification, annealing of the probe to the target sequence creates a substrate that can be cleaved by the 5'- 10 exonuclease activity of Taq polymerase. During the extension phase of the PCR amplification cycle, cleavage of the probe by Taq polymerase releases the reporter dye from the remainder of the probe (and hence from the quencher moiety) and a sequence-specific fluorescent signal is 15 generated. With each cycle, additional reporter dye molecules are cleaved from their respective probes, and the fluorescence intensity is monitored at regular intervals by laser optics built into the ABI PRISM™ 7700 Sequence Detection System. In each assay, a series of parallel 20 reactions containing serial dilutions of mRNA from untreated control samples generates a standard curve that is used to quantitate the percent inhibition after antisense oligonucleotide treatment of test samples.

PCR reagents were obtained from PE-Applied Biosystems, 25 Foster City, CA. RT-PCR reactions were carried out by adding 25 µL PCR cocktail (1x TAQMAN™ buffer A, 5.5 mM MgCl₂, 300 µM each of dATP, dCTP and dGTP, 600 µM of dUTP, 100 nM each of forward primer, reverse primer, and probe, 20 Units RNase inhibitor, 1.25 Units AMPLITAQ GOLD™, and 30 12.5 Units MuLV reverse transcriptase) to 96 well plates containing 25 µL poly(A) mRNA solution. The RT reaction was carried out by incubation for 30 minutes at 48°C. Following a 10 minute incubation at 95°C to activate the AMPLITAQ GOLD™, 40 cycles of a two-step PCR protocol were 35 carried out: 95°C for 15 seconds (denaturation) followed by

-78-

60°C for 1.5 minutes (annealing/extension). Protein kinase C-theta probes and primers were designed to hybridize to the human Protein kinase C-theta sequence, using published sequence information (GenBank accession number L01087,
5 incorporated herein as SEQ ID NO:3).

For Protein kinase C-theta the PCR primers were:
forward primer: AAACCACCGTGGAGCTCTACTC (SEQ ID NO: 4)
reverse primer: CATTGGCCTTGAGGTTCA (SEQ ID NO: 5) and the
PCR probe was: FAM-CTGAGAGGTGCAGGAAGAACACGGGA-TAMRA
10 (SEQ ID NO: 6) where FAM (PE-Applied Biosystems, Foster
City, CA) is the fluorescent reporter dye) and TAMRA (PE-
Applied Biosystems, Foster City, CA) is the quencher dye.

For GAPDH the PCR primers were:
forward primer: GAAGGTGAAGGTCGGAGTC (SEQ ID NO: 7)
15 reverse primer: GAAGATGGTGATGGGATTT (SEQ ID NO: 8) and the
PCR probe was: 5' JOE-CAAGCTTCCGTTCTCAGCC- TAMRA 3' (SEQ
ID NO: 9) where JOE (PE-Applied Biosystems, Foster City,
CA) is the fluorescent reporter dye) and TAMRA (PE-Applied
Biosystems, Foster City, CA) is the quencher dye.

20 **Example 14**

**Northern blot analysis of Protein kinase C-theta mRNA
levels**

Eighteen hours after antisense treatment, cell monolayers were washed twice with cold PBS and lysed in 1
25 mL RNAZOL™ (TEL-TEST "B" Inc., Friendswood, TX). Total RNA was prepared following manufacturer's recommended
protocols. Twenty micrograms of total RNA was fractionated by electrophoresis through 1.2% agarose gels containing
1.1% formaldehyde using a MOPS buffer system (AMRESCO, Inc.
30 Solon, OH). RNA was transferred from the gel to HYBOND™-N+
nylon membranes (Amersham Pharmacia Biotech, Piscataway,
NJ) by overnight capillary transfer using a Northern/Southern Transfer buffer system (TEL-TEST "B"
Inc., Friendswood, TX). RNA transfer was confirmed by UV
35 visualization. Membranes were fixed by UV cross-linking

- 79 -

using a STRATALINKER™ UV Crosslinker 2400 (Stratagene, Inc, La Jolla, CA).

Membranes were probed using QUICKHYB™ hybridization solution (Stratagene, La Jolla, CA) using manufacturer's recommendations for stringent conditions with a Protein kinase C-theta specific probe prepared by PCR using the forward primer AAACCACCGTGGAGCTCTACTC (SEQ ID NO: 4) and the reverse primer CATTCGGCCTTGAGGTTCA (SEQ ID NO: 5). To normalize for variations in loading and transfer efficiency membranes were stripped and probed for glyceraldehyde-3-phosphate dehydrogenase (GAPDH) RNA (Clontech, Palo Alto, CA). Hybridized membranes were visualized and quantitated using a PHOSPHORIMAGER™ and IMAGEQUANT™ Software V3.3 (Molecular Dynamics, Sunnyvale, CA). Data was normalized to GAPDH levels in untreated controls.

Example 15:

Antisense inhibition of Protein kinase C-theta expression-phosphorothioate 2'-MOE gapmer oligonucleotides

In accordance with the present invention, a series of oligonucleotides targeted to human Protein kinase C-theta were synthesized. The oligonucleotide sequences are shown in Table 1. Target sites are indicated by nucleotide numbers, as given in the sequence source reference (Genbank accession no. L01087, incorporated herein as SEQ ID NO: 3), to which the oligonucleotide binds.

All compounds in Table 1 are chimeric oligonucleotides ("gapmers") 20 nucleotides in length, composed of a central "gap" region consisting of ten 2'-deoxynucleotides, which is flanked on both sides (5' and 3' directions) by five-nucleotide "wings". The wings are composed of 2'-methoxyethyl (2'-MOE) nucleotides. The internucleoside (backbone) linkages are phosphorothioate (P=S) throughout the oligonucleotide. Cytidine residues in the 2'-MOE wings are 5-methylcytidines.

-80-

Data were obtained by real-time quantitative PCR as described in other examples herein and are averaged from two experiments. If present, "N.D." indicates "no data".

5

Table 1

Inhibition of Protein kinase C-theta mRNA levels by
chimeric phosphorothioate oligonucleotides having 2'-MOE
wings and a deoxy gap

	ISIS#	REGION	TARGET	SEQUENCE	% Inhib.	SEQ ID NO.
			SITE			
10	109349	5' UTR	35	tggcgctggactgcgcggg	49	10
	109350	Start Codon	76	tggttgcgcctggagcgag	59	11
	109351	Start Codon	84	tggcgacatggttgcgcct	70	12
	109352	Start Codon	89	agaaatggcgacatggttgc	69	13
15	109353	Start Codon	97	caatccgaagaaatggcgac	72	14
	109354	Coding	139	cctgacaagactggcaggac	86	15
	109355	Coding	183	atactcttgacgagcacag	71	16
	109356	Coding	243	ccagggtgggtacatggtag	23	17
	109357	Coding	286	gcataactttcccttggttg	84	18
20	109358	Coding	345	gtagagctccacggtggtt	96	19
	109359	Coding	388	tttctgtcttcccgttgc	86	20
	109360	Coding	431	gcattcatttagcattcgcc	81	21
	109361	Coding	474	ttcattcatgtccttgcgt	76	22
	109362	Coding	517	caccggcgctgatgaaa	90	23
25	109363	Coding	559	actcggtgcacttgacgtgg	76	24
	109364	Coding	600	gacagagcaaaatgtggct	60	25
	109365	Coding	642	ctggtagccctgtttgtca	82	26
	109366	Coding	685	tatcaatacacttcttgcgt	90	27
	109367	Coding	727	ctcggttattgatagctgt	44	28
30	109368	Coding	768	tggcatgtcaattttgaatc	76	29
	109369	Coding	810	acagaaggctgggtcttgt	73	30
	109370	Coding	852	tccttgccgtgccagtcccc	78	31
	109371	Coding	893	catctatgatgcacattcat	22	32
	109372	Coding	935	agcttctggtttatgccaca	92	33
35	109373	Coding	978	agcctgttggatgtctcaa	88	34
	109374	Coding	1020	cggacattctctgtggatct	82	35
	109375	Coding	1078	tcggtaaacatggcagcctt	52	36
	109376	Coding	1136	tccacctcatccaacggaga	89	37
	109377	Coding	1178	ctttctttgttcagttcagg	84	38

-81-

109378	Coding	1235	cccaacatggtgcaagat	90	39	
109379	Coding	1276	tcttgaattctgccaggaa	63	40	
109380	Coding	1332	gtccatcaagaccacatctt	76	41	
109381	Coding	1374	ggaaagaactctttctcta	53	42	
5	109382	Coding	1416	tgtacaaaacatgtgcgtca	81	43
109383	Coding	1475	attaagtcccctccgtttag	52	44	
109384	Coding	1517	gctctggaaagggtcgaaactt	65	45	
109385	Coding	1559	aggaaactgcagaccaagaat	53	46	
109386	Coding	1601	ttatcttagttcaggccct	68	47	
10	109387	Coding	1642	aatccgcgatcttgatatgt	36	48
109388	Coding	1683	cgtcttggcatctcctaaca	79	49	
109389	Coding	1742	tatttctgaccaggcaagat	40	50	
109390	Coding	1784	taaaggagaaccccgaaagga	55	51	
15	109391	Coding	1825	catcctgcccgtggaaaggc	80	52
109392	Coding	1841	tggaaagagctctcctcatc	62	53	
109393	Coding	1865	aagggattgtccatgcggat	0	54	
109394	Coding	1907	accagaaggtccttgcattc	54	55	
109395	Coding	1947	cacgcccagcctcttcag	54	56	
109396	Coding	1988	ttgatctcccggaaacaaagg	53	57	
20	109397	Coding	2004	ttcaagttcctccagggtga	44	58
109398	Coding	2029	ggaacgggtgggtcaatctcc	56	59	
109399	Coding	2070	gtcgaaattgctgcagtcaa	62	60	
109400	Coding	2127	gttgatcagtgcgtgtcgg	60	61	
109401	Coding	2169	gttcatgaaggaaaagttcc	52	62	
25	109402	Coding	2194	aggatatcagccgctccatc	77	63
109403	Stop Codon	2196	tcaggatatcagccgctcca	80	64	
109404	Stop Codon	2198	attcaggatatcagccgctc	74	65	
109405	Stop Codon	2200	agattcaggatatcagccgc	37	66	
109406	Stop Codon	2202	caagattcaggatatcagcc	56	67	
30	109407	Stop Codon	2204	ggcaagattcaggatatcag	74	68
109408	3' UTR	2223	tctttcctgtctggagggg	69	69	
109409	3' UTR	2243	ttcccaggacaaggcaaat	14	70	
109410	3' UTR	2265	caagcagtgtcttgaacc	73	71	
109411	3' UTR	2316	cagtctttattgtttagtgt	68	72	
35	109412	3' UTR	2355	tctgctacagataaaagtca	71	73
109413	3' UTR	2374	tagtgaagttagacttggtt	59	74	
109414	3' UTR	2396	acgagacacacggcatcg	77	75	
109415	3' UTR	2419	gcgtctgtgagacatgtcag	58	76	
109416	3' UTR	2438	taatgacctaacttcaggag	56	77	
40	109417	3' UTR	2463	ctttcaagtaataactatg	34	78
109418	3' UTR	2480	caagtgcggagacccatctt	73	79	

-82-

109419	3'	UTR	2504	cagtatcaagtcttcaaacc	56	80	
109420	3'	UTR	2522	aagaggccataatttattgca	63	81	
109421	3'	UTR	2544	atcagcagttgcgcggcagg	39	82	
109422	3'	UTR	2563	ttcaacaaggcatttcgttga	53	83	
5	109423	3'	UTR	2585	tctgtactccgttgcacct	71	84
	109424	3'	UTR	2604	ccgtttcagtcttgagacgt	62	85
	109425	3'	UTR	2642	cggtctgagtgagatccgcta	65	86
	109426	3'	UTR	2663	gggttagtgattacttgtct	41	87
	109427	3'	UTR	2676	aatagaataaaacgggttag	40	88
	109428	3'	UTR	2723	aaacctatccaggcgtggcc	53	89

As shown in Table 1, SEQ ID NOS 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 15 49, 51, 52, 53, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 67, 68, 69, 71, 72, 73, 74, 75, 76, 77, 79, 80, 81, 83, 84, 85, 86 and 89 demonstrated at least 45% inhibition of Protein kinase C-theta expression in this experiment and are therefore preferred.

20 Example 16

Western blot analysis of Protein kinase C-theta protein levels

Western blot analysis (immunoblot analysis) is carried out using standard methods. Cells are harvested 16-20 h 25 after oligonucleotide treatment, washed once with PBS, suspended in Laemmli buffer (100 ul/well), boiled for 5 minutes and loaded on a 16% SDS-PAGE gel. Gels are run for 1.5 hours at 150 V, and transferred to membrane for western blotting. Appropriate primary antibody directed to Protein 30 kinase C-theta is used, with a radiolabelled or fluorescently labeled secondary antibody directed against the primary antibody species. Bands are visualized using a PHOSPHORIMAGER™ (Molecular Dynamics, Sunnyvale CA).

-83-

What is claimed is:

1. An antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human Protein kinase C-theta, wherein said antisense compound 5 specifically hybridizes with and inhibits the expression of human Protein kinase C-theta.
2. The antisense compound of claim 1 which is an antisense oligonucleotide.
3. The antisense compound of claim 2 wherein the 10 antisense oligonucleotide has a sequence comprising SEQ ID NO: 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 51, 52, 53, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 67, 68, 69, 71, 72, 73, 74, 75, 76, 77, 15 79, 80, 81, 83, 84, 85, 86 or 89.
4. The antisense compound of claim 2 wherein the antisense oligonucleotide comprises at least one modified internucleoside linkage.
5. The antisense compound of claim 4 wherein the 20 modified internucleoside linkage is a phosphorothioate linkage.
6. The antisense compound of claim 2 wherein the antisense oligonucleotide comprises at least one modified sugar moiety.
- 25 7. The antisense compound of claim 6 wherein the modified sugar moiety is a 2'-O-methoxyethyl sugar moiety.
8. The antisense compound of claim 2 wherein the antisense oligonucleotide comprises at least one modified nucleobase.
- 30 9. The antisense compound of claim 8 wherein the modified nucleobase is a 5-methylcytosine.
10. The antisense compound of claim 2 wherein the antisense oligonucleotide is a chimeric oligonucleotide.
11. A composition comprising the antisense compound

-84-

of claim 1 and a pharmaceutically acceptable carrier or diluent.

12. The composition of claim 11 further comprising a colloidal dispersion system.

13. The composition of claim 11 wherein the
5 antisense compound is an antisense oligonucleotide.

14. A method of inhibiting the expression of Protein kinase C-theta in human cells or tissues comprising contacting said cells or tissues with the antisense compound of claim 1 so that expression of Protein kinase C-
10 theta is inhibited.

15. A method of treating a human having a disease or condition associated with Protein kinase C-theta comprising administering to said animal a therapeutically or prophylactically effective amount of the antisense compound
15 of claim 1 so that expression of Protein kinase C-theta is inhibited.

16. The method of claim 15 wherein the disease or condition is diabetes.

17. The method of claim 15 wherein the disease or
20 condition is AIDS.

18. The method of claim 15 wherein the disease or condition is a wound healing disorder.

19. The method of claim 15 wherein the disease or condition is a hyperproliferative disorder.

25 20. The method of claim 19 wherein the hyperproliferative disorder is cancer.

SEQUENCE LISTING

<110> C. Frank Bennett
 Lex M. Cowser
 ISIS PHARMACEUTICALS, INC.

<120> ANTISENSE MODULATION OF PROTEIN KINASE C-THETA
 EXPRESSION

<130> RTSP-0069

<150> 09/429,322
<151> 1999-10-26

<160> 89

<210> 1
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 1
tccgtcatcg ctcctcaggg 20

<210> 2
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 2
atgcattctg cccccaagga 20

<210> 3
<211> 2754
<212> DNA
<213> Homo sapiens

<220>
<221> CDS
<222> (95)..(2215)

<400> 3
gaattccgcc agcccccgc gtcggcgca agtccccgcg cagtcccagc gccacccggc 60

agcagcggcg ccgtgctcgc tccaggcgca aacc atg tcg cca ttt ctt cgg 112
Met Ser Pro Phe Leu Arg
1 5

att ggc ttg tcc aac ttt gac tgc ggg tcc tgc cag tct tgt cag ggc 160
Ile Gly Leu Ser Asn Phe Asp Cys Gly Ser Cys Gln Ser Cys Gln Gly
10 15 20

gag gct gtt aac cct tac tgt gct gtg ctc gtc aaa gag tat gtc gaa 208
Glu Ala Val Asn Pro Tyr Cys Ala Val Leu Val Lys Glu Tyr Val Glu
25 30 35

tca gag aac ggg cag atg tat atc cag aaa aag cct acc atg tac cca Ser Glu Asn Gly Gln Met Tyr Ile Gln Lys Lys Pro Thr Met Tyr Pro 40 45 50	256
ccc tgg gac agc act ttt gat gcc cat atc aac aag gga aga gtc atg Pro Trp Asp Ser Thr Phe Asp Ala His Ile Asn Lys Gly Arg Val Met 55 60 65 70	304
cag atc att gtg aaa ggc aaa aac gtg gac ctc atc tct gaa acc acc Gln Ile Ile Val Lys Gly Lys Asn Val Asp Leu Ile Ser Glu Thr Thr 75 80 85	352
gtg gag ctc tac tcg ctg gct gag agg tgc agg aag aac aac ggg aag Val Glu Leu Tyr Ser Leu Ala Glu Arg Cys Arg Lys Asn Asn Gly Lys 90 95 100	400
aca gaa ata tgg tta gag ctg aaa cct caa ggc cga atg cta atg aat Thr Glu Ile Trp Leu Glu Leu Lys Pro Gln Gly Arg Met Leu Met Asn 105 110 115	448
gca aga tac ttt ctg gaa atg agt gac aca aag gac atg aat gaa ttt Ala Arg Tyr Phe Leu Glu Met Ser Asp Thr Lys Asp Met Asn Glu Phe 120 125 130	496
gag acg gaa ggc ttc ttt gct ttg cat cag cgc cggt gcc atc aag Glu Thr Glu Gly Phe Ala Leu His Gln Arg Arg Gly Ala Ile Lys 135 140 145 150	544
cag gca aag gtc cac cac gtc aag tgc cac gag ttc act gcc acc ttc Gln Ala Lys Val His His Val Lys Cys His Glu Phe Thr Ala Thr Phe 155 160 165	592
ttc cca cag ccc aca ttt tgc tct gtc tgc cac gag ttt gtc tgg ggc Phe Pro Gln Pro Thr Phe Cys Ser Val Cys His Glu Phe Val Trp Gly 170 175 180	640
ctg aac aaa cag ggc tac cag tgc cga caa tgc aat gca gca att cac Leu Asn Lys Gln Gly Tyr Gln Cys Arg Gln Cys Asn Ala Ala Ile His 185 190 195	688
aag aag tgt att gat aaa gtt ata gca aag tgc aca gga tca gct atc Lys Lys Cys Ile Asp Lys Val Ile Ala Lys Cys Thr Gly Ser Ala Ile 200 205 210	736
aat agc cga gaa acc atg ttc cac aag gag aga ttc aaa att gac atg Asn Ser Arg Glu Thr Met Phe His Lys Glu Arg Phe Lys Ile Asp Met 215 220 225 230	784
cca cac aga ttt aaa gtc tac aat tac aag agc ccg acc ttc tgt gaa Pro His Arg Phe Lys Val Tyr Asn Tyr Lys Ser Pro Thr Phe Cys Glu 235 240 245	832
cac tgt ggg acc ctg ctg tgg gga ctg gca cgg caa gga ctc aag tgt His Cys Gly Thr Leu Leu Trp Gly Leu Ala Arg Gln Gly Leu Lys Cys 250 255 260	880
gat gca tgt ggc atg aat gtg cat cat aga tgc cag aca aag gtg gcc Asp Ala Cys Gly Met Asn Val His His Arg Cys Gln Thr Lys Val Ala 265 270 275	928

aac ctt tgt ggc ata aac cag aag cta atg gct gaa gcg ctg gcc atg Asn Leu Cys Gly Ile Asn Gln Lys Leu Met Ala Glu Ala Leu Ala Met 280 285 290	976
att gag agc actcaa cag gct cgc tgc tta aga gat act gaa cag atc Ile Glu Ser Thr Gln Gln Ala Arg Cys Leu Arg Asp Thr Glu Gln Ile 295 300 305	1024
ttc aga gaa ggt ccg gtt gaa att ggt ctc cca tgc tcc atc aaa aat Phe Arg Glu Gly Pro Val Glu Ile Gly Leu Pro Cys Ser Ile Lys Asn 315 320 325	1072
gaa gca agg ctg cca tgt tta ccg aca ccg gga aaa aga gag cct cag Glu Ala Arg Leu Pro Cys Leu Pro Thr Pro Gly Lys Arg Glu Pro Gln 330 335 340	1120
ggc att tcc tgg gag tct ccg ttg gat gag gtg gat aaa atg tgc cat Gly Ile Ser Trp Glu Ser Pro Leu Asp Glu Val Asp Lys Met Cys His 345 350 355	1168
ctt cca gaa cct gaa ctg aac aaa gaa aga cca tct ctg cag att aaa Leu Pro Glu Pro Glu Leu Asn Lys Glu Arg Pro Ser Leu Gln Ile Lys 360 365 370	1216
cta aaa att gag gat ttt atc ttg cac aaa atg ttg ggg aaa gga agt Leu Lys Ile Glu Asp Phe Ile Leu His Lys Met Leu Gly Lys Gly Ser 375 380 385	1264
ttt ggc aag gtc ttc ctg gca gaa ttc aag aaa acc aat caa ttt ttc Phe Gly Lys Val Phe Leu Ala Glu Phe Lys Lys Thr Asn Gln Phe Phe 395 400 405	1312
gca ata aag gcc tta aag aaa gat gtg gtc ttg atg gac gat gat gtt Ala Ile Lys Ala Leu Lys Asp Val Val Leu Met Asp Asp Asp Val 410 415 420	1360
gag tgc acg atg gta gag aag aga gtt ctt tcc ttg gcc tgg gag cat Glu Cys Thr Met Val Glu Lys Arg Val Leu Ser Leu Ala Trp Glu His 425 430 435	1408
ccg ttt ctg acg cac atg ttt tgt aca ttt cag acc aag gaa aac ctc Pro Phe Leu Thr His Met Phe Cys Thr Phe Gln Thr Lys Glu Asn Leu 440 445 450	1456
ttt ttt gtg atg gag tac ctc aac gga ggg gac tta atg tac cac atc Phe Phe Val Met Glu Tyr Leu Asn Gly Gly Asp Leu Met Tyr His Ile 455 460 465	1504
caa agc tgc cac aag ttc gac ctt tcc aga gcg acg ttt tat gct gct Gln Ser Cys His Lys Phe Asp Leu Ser Arg Ala Thr Phe Tyr Ala Ala 475 480 485	1552
gaa atc att ctt ggt ctg cag ttc ctt cat tcc aaa gga ata gtc tac Glu Ile Ile Leu Gly Leu Gln Phe Leu His Ser Lys Gly Ile Val Tyr 490 495 500	1600
agg gac ctg aag cta gat aac atc ctg tta gac aaa gat gga cat atc Arg Asp Leu Lys Leu Asp Asn Ile Leu Leu Asp Lys Asp Gly His Ile 505 510 515	1648

aag atc gcg gat ttt gga atg tgc aag gag aac atg tta gga gat gcc Lys Ile Ala Asp Phe Gly Met Cys Lys Glu Asn Met Leu Gly Asp Ala 520 525 530	1696
aag acg aat acc ttc tgt ggg aca cct gac tac atc gcc cca gag atc Lys Thr Asn Thr Phe Cys Gly Thr Pro Asp Tyr Ile Ala Pro Glu Ile 535 540 545	1744
ttg ctg ggt cag aaa tac aac cac tct gtg gac tgg tgg tcc ttc ggg Leu Leu Gly Gln Lys Tyr Asn His Ser Val Asp Trp Trp Ser Phe Gly 555 560 565	1792
gtt ctc ctt tat gaa atg ctg att ggt cag tcg cct ttc cac ggg cag Val Leu Leu Tyr Glu Met Leu Ile Gly Gln Ser Pro Phe His Gly Gln 570 575 580	1840
gat gag gag gag ctc ttc cac tcc atc cgc atg gac aat ccc ttt tac Asp Glu Glu Glu Leu Phe His Ser Ile Arg Met Asp Asn Pro Phe Tyr 585 590 595	1888
cca cg ^g tgg ctg gag aag gaa gca aag gac ctt ctg gtg aag ctc ttc Pro Arg Trp Leu Glu Lys Glu Ala Lys Asp Leu Leu Val Lys Leu Phe 600 605 610	1936
gtg cga gaa cct gag aag agg ctg ggc gtg agg gga gac atc cgc cag Val Arg Glu Pro Glu Lys Arg Leu Gly Val Arg Gly Asp Ile Arg Gln 615 620 625	1984
cac cct ttg ttt cgg gag atc aac tgg gag gaa ctt gaa cg ^g aag gag His Pro Leu Phe Arg Glu Ile Asn Trp Glu Glu Leu Glu Arg Lys Glu 635 640 645	2032
att gac cca ccg ttc cgg c ^g aaa gtg aaa tca cca ttt gac tgc agc Ile Asp Pro Pro Phe Arg Pro Lys Val Lys Ser Pro Phe Asp Cys Ser 650 655 660	2080
aat ttc gac aaa gaa ttc tta aac gag aag ccc cg ^g ctg tca ttt gcc Asn Phe Asp Lys Glu Phe Leu Asn Glu Lys Pro Arg Leu Ser Phe Ala 665 670 675	2128
gac aga gca ctg atc aac agc atg gac cag aat atg ttc agg aac ttt Asp Arg Ala Leu Ile Asn Ser Met Asp Gln Asn Met Phe Arg Asn Phe 680 685 690	2176
tcc ttc atg aac ccc cg ^g atg gag cg ^g ctg ata tcc tga atcttgcccc Ser Phe Met Asn Pro Arg Met Glu Arg Leu Ile Ser 695 700 705	2225
tccagagaca ggaaagaatt tgcc ^t gtcc ctgggaactg gttcaagaga cactgcttgg gttcctttt caacttggaa aaagaaagaa acactcaaca ataaagactg agaccggttc	2285 2345
gcccccatgt gactttatac t ^t tagcagaa accaagtcta ct ^t acta ^t gacgatgccg	2405
tgtgtctcgt ctcc ^t gacat gtctcacaga cgctcc ^t gaa gtttaggtcat tactaaccat	2465
agtttattac ttgaaagatg ggtctccgca ct ^t ggaaagg tttcaagact tgatactgca	2525
ataaattatg gctcttcacc tggcgccaa ctgctgatca acgaaaatgct tg ^t gaatca	2585
ggggcaaacg gagtacagac gtctcaagac tgaaacggcc ccattgcctg gtctagtagc	2645

ggatctcaact cagccgcaga caagtaatca ctaacccgtt ttattctatt cctatctgtg 2705
gatgggtaaa tgctggggc cagccctgga taggtttta tggaaattc
2754

<210> 4
<211> 22
<212> DNA
<213> Artificial Sequence

<223> PCR Primer

<400> 4
aaaccaccgt ggagctctac tc 22

<210> 5
<211> 20
<212> DNA
<213> Artificial Sequence

<223> PCR Primer

<400> 5
cattcggcct tgaggttca 20

<210> 6
<211> 27
<212> DNA
<213> Artificial Sequence

<223> PCR Probe

<400> 6
ctgagaggtg caggaagaac aacggga 27

<210> 7
<211> 19
<212> DNA
<213> Artificial Sequence

<223> PCR Primer

<400> 7
gaaggtgaag gtcggagt 19

<210> 8
<211> 20
<212> DNA
<213> Artificial Sequence

<223> PCR Primer

<400> 8
gaagatggtg atgggatttc 20

<210> 9
<211> 20

<212> DNA
<213> Artificial Sequence

<223> PCR Probe

<400> 9
caagcttccc gttctcagcc

20

<210> 10
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 10
tggcgctggg actgcgcggg

20

<210> 11
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 11
tggttgcgcc ctggagcgg

20

<210> 12
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 12
tggcgacatg gttgcgcct

20

<210> 13
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 13
agaaaatggcg acatggttgc

20

<210> 14
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 14
caatccgaag aaatggcgcac

20

<210> 15
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 15
cctgacaaga ctggcaggac 20

<210> 16
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 16
ataactcttg acgagcacag 20

<210> 17
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 17
ccaggggtgg tacatggtag 20

<210> 18
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 18
gcatgactt tcccttgttg 20

<210> 19
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 19
gttagagctcc acgggtggtt 20

<210> 20
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 20

tttctgtctt cccgttgttc

20

<210> 21
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 21

gcattcatta gcattcgccc

20

<210> 22
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 22

ttcattcatg tcctttgtgt

20

<210> 23
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 23

caccccggcg ctgatgcaaa

20

<210> 24
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 24

actcgtggca cttgacgtgg

20

<210> 25
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 25

gacagagcaa aatgtggct

20

<210> 26
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 26

ctggtagccc tgtttggca

20

<210> 27

<211> 20

<212> DNA

<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 27

tatcaataaca cttcttgtga

20

<210> 28

<211> 20

<212> DNA

<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 28

ctcggctatt gatagctgat

20

<210> 29

<211> 20

<212> DNA

<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 29

tggcatgtca attttgaatc

20

<210> 30

<211> 20

<212> DNA

<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 30

acagaaggtc gggctcttgt

20

<210> 31

<211> 20

<212> DNA

<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 31

tccttgccgt gccagtcggc

20

<210> 32

<211> 20

<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 32
catctatgtat gcacattcat

20

<210> 33
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 33
agcttctgggt ttatgccaca

20

<210> 34
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 34
agcctgttga gtgctctcaa

20

<210> 35
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 35
cgcacccctt ctgaagatct

20

<210> 36
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 36
tcggtaaaca tggcagcctt

20

<210> 37
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 37
tccacccat ccaacggaga

20

<210> 38
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 38
ctttctttgt tcagttcagg

20

<210> 39
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 39
cccaacattt tgtgcaagat

20

<210> 40
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 40
tcttgaaattc tgccaggaag

20

<210> 41
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 41
gtccatcaag accacatctt

20

<210> 42
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 42
ggaaagaact ctcttctcta

20

<210> 43
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 43

tgtacaaaac atgtgcgtca 20

<210> 44
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 44
atthaagtccc ctccgtttag 20

<210> 45
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 45
gctctggaaa ggtcgaaactt 20

<210> 46
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 46
aggaactgca gaccaagaat 20

<210> 47
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 47
ttatcttagct tcaggtccct 20

<210> 48
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 48
aatccgcgat cttgatatgt 20

<210> 49
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide
<400> 49
cgtcttggca tctccctaaca 20

<210> 50
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 50
tatttctgac ccagcaagat 20

<210> 51
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 51
taaaggagaa ccccgaaagga 20

<210> 52
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 52
catcctgccc gtggaaaaggc 20

<210> 53
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 53
tggaagagct cctcctcatac 20

<210> 54
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 54
aaggggattgt ccatgcggat 20

<210> 55
<211> 20

<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 55
accagaaggc ccttgcttc

20

<210> 56
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 56
cacggccagc ctcttctcag

20

<210> 57
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 57
ttgatctccc gaaacaaaagg

20

<210> 58
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 58
ttcaagttcc tcccagttga

20

<210> 59
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 59
ggaacgggtgg gtcaatctcc

20

<210> 60
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 60
gtcgaaattg ctgcagtcaa

20

<210> 61
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 61
gttgatcagt gctctgtcgg 20

<210> 62
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 62
gttcatgaag gaaaagttcc 20

<210> 63
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 63
aggatatcag ccgcgtccatc 20

<210> 64
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 64
tcaggatatac agccgctcca 20

<210> 65
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 65
attcaggata tcagccgctc 20

<210> 66
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 66

agattcagga tatacgccgc

20

<210> 67
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 67

caagattcag gatatacgcc

20

<210> 68
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 68

ggcaagattc aggtatcag

20

<210> 69
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 69

tcttcctgt ctctggaggg

20

<210> 70
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 70

ttcccaggaa caaggaaat

20

<210> 71
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 71

caagcagtgt ctcttgaacc

20

<210> 72
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 72
cagtctttat tgttgagtgt

20

<210> 73
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 73
tctgctacag ataaaaagtca

20

<210> 74
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 74
tagtgaagta gacttggttt

20

<210> 75
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 75
acgagacaca cggcatcgac

20

<210> 76
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 76
gcgtctgtga gacatgtcag

20

<210> 77
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 77
taatgaccta acttcaggag

20

<210> 78
<211> 20
<212> DNA

<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 78
ctttcaagta aataactatg

20

<210> 79
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 79
caagtgcgga gacccatctt

20

<210> 80
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 80
cagtatcaag tcttgaaacc

20

<210> 81
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 81
aagagccata atttattgca

20

<210> 82
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 82
atcagcagtt ggcccagg

20

<210> 83
<211> 20
<212> DNA
<213> Artificial Sequence
<223> Antisense Oligonucleotide
<400> 83
ttcaacaagc atttcgttga

20

<210> 84
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 84
tctgtactcc gtttgccccct 20

<210> 85
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 85
ccgtttcagt cttgagacgt 20

<210> 86
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 86
cggctgagtg agatccgcta 20

<210> 87
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 87
gggttagtga ttacttgtct 20

<210> 88
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 88
aatagaataa aacgggttag 20

<210> 89
<211> 20
<212> DNA
<213> Artificial Sequence

<223> Antisense Oligonucleotide

<400> 89
aaacacctatcc agggctggcc 20